KONSO BENCH TERRACE - ETHIOPIA

The traditional Konso Bench Terraces are established by building up stone embankments along the contour and gradually levelling the land in between risers. Levelling is done actively and by siltation processes. Stone walls have to be enhanced periodically. The appearance of the technology evolves over time from stone embankments to bench terraces. The stone walls are supported on the downslope side by trees and / or legumes including coffee, pigeon pea, etc. The purpose of the structures is to break the slope length and reduce run-off concentration thereby controlling erosion, increasing water stored in soil and harvesting eroded sediments.
Terraces have a long tradition in the area, and farmers are specialists in construction of stone walls. The first step during terrace establishment is to dig foundation up to 30 cm. Then stone walls are gradually built up to an impressive height of 1.5 - 2 m above the ground. The technology is very labour intensive: Establishment takes 5 years and bi-annual maintenance is required. However, it is worth the effort, since without terracing crop production would not be thinkable in a marginal area characterised by shortage and high variability of rainfall, shallow, stony soils on steep slopes, high levels of soil erosion and (thus) frequent food shortages.
Social systems for labour-sharing and voluntary assistance have evolved to manage heavy labour inputs. Multiple cropping is practised for risk aversion. Growing leguminous crops helps to further improve soil fertility. Additional water harvesting measures are needed to further raise yields.

SLM measure	Structural combined with vegetative
SLM group	Cross-Slope Barriers
Land use type	Annual cropping
Degradation addressed	Soil erosion; Fertility decline; Aridification / soil moisture problem
Stage of intervention	Rehabilitation and mitigation
Tolerance to climate change	Tolerant to climatic extremes (e.g. rain storms). Water conservation effect increases resilience to periods of water stress

Establishment activities

1. Survey / layout.
2. Collecting stones.
3. Digging foundation (0.3 m deep; 0.3 m wide).
4. Establish stone wall (0.7 m high).
5. Land levelling.
6. Option: plant trees on the upper part of the stone riser.

All activities carried out by manual labour, using water level, poles, scoop hoe, spade. All activities carried out in the dry season.

Maintenance / recurrent activities

1. Stabilising terraces / enhancing walls by putting additional stones.
2. Repairing broken terraces and replanting of vegetative material.
3. Include inter-terrace management measures.

All activities carried out by manual labour, using crowbar, hammer,
hoe, spade (1-2 times a year).

Labour requirements

For establishment: very high
For maintenance: high

Knowledge requirements

For advisors: moderate
For land users: moderate

Photo 1 and 2: Meticulously built terrace risers reaching a height of 1.5 – 2 meters; frequent maintenance is needed to enhance risers and repair breaches.
Photo 3: Bench terraces with maize, cassava and sunflowers.
Photo 4: Overview of a terraced hillside with annual crops and trees. (All photos by Hanspeter Liniger)

Case study area: Konso; Ethiopia

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour: 1,650 person-days)	1,650
Equipment	70
Agricultural inputs: seeds and manure	40
Construction material: stones	300
TOTAL	**2,060**

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour: 25-30% person-days of establishment	500
Equipment	0
Agricultural inputs	40
TOTAL	**540**

Remarks: Duration of establishment phase is 5 years. Land users maintain the terrace at least twice a year, mainly while preparing the land for crops. Labour inputs for maintenance are usually 25-30% of construction. Daily wage of hired labour is about US$ 1; material costs include collection and sizing of stones.

Benefit-cost ratio

Inputs	short term	long term
Establishment	negative	slightly positive
Maintenance	slightly positive	positive

Remarks: The profit is very marginal but without the terraces no harvest is expected. The land users continue to invest on the terraces as long as they can make a living from the land this way.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 500-750 mm
- Soil parameters: low to very low fertility, low soil organic matter, good drainage
- Slope: moderate – hilly (5-30%)
- Landform: hillslopes and footslopes, ridges
- Altitude: 1,500 - 2,500 m a.s.l.

Socio-economic conditions

- Size of land per household: 0.5-1.5 ha
- Type of land user: poor / better-off small-scale farmers; in groups or individually
- Population density: 50-100 persons/km^2
- Land ownership: state
- Land use rights: individual
- Market orientation: mostly subsistence
- Level of mechanisation: manual labour

Production / economic benefits

+++ Increased crop yields: sorghum yield raised by 50% (from 0.4 t/ha to 0.6 t/ha)
++ Increased farm income

Ecological benefits

+++ Reduced soil loss (>50%)
+++ Reduced runoff (60%)
++ Increased infiltration and increased soil moisture
++ Increased soil organic matter (sediment harvesting)

Socio-cultural benefits

+ Social organisation: establishment of community organisations and strengthening of groups
+ Maintenance of cultural heritage

Off-site benefits

++ Reduced downstream siltation
+ Reduced downstream flooding

Weaknesses ➜ and how to overcome

- The terraces require very frequent maintenance which makes the technology highly labour-demanding ➜ use bigger stones for construction; avoid free grazing (animals damage the structures).

Adoption

The technology is wide-spread in the case study area, covering approx. 1200 km^2. 90% of land users have implemented the terraces without receiving any external support other than technical guidance.

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Key references: Danano D. 2008 (unpublished). Soil and Water Conservation Practices for Sustainable Land Management in Ethiopia. Ethiocat. ■ WOCAT. 2002. WOCAT database on SLM technologies. www.wocat.net.

AGROFORESTRY

High diversity in an agroforestry system, Ethiopia. (Hanspeter Liniger)

In a nutshell

Definition: Agroforestry (AF) is a collective name for land use systems and practices in which woody perennials are deliberately integrated with agricultural crops and / or livestock for a variety of benefits and services. The integration can be either in a spatial mixture (e.g. crops with trees) or in a temporal sequence (e.g. improved fallows, rotation). AF ranges from very simple and sparse to very complex and dense systems. It embraces a wide range of practices: alley cropping, farming with trees on contours, or perimeter fencing with trees, multi-storey cropping, relay cropping, intercropping, multiple cropping, bush and tree fallows, parkland systems, homegardens etc.; many of them are traditional land-use systems. AF is thus not a single technology but covers the broad concept of trees being integrated into cropping and livestock systems in order to achieve multifunctionality. There is no clear boundary between AF and forestry, nor between AF and agriculture.

Applicability: On subhumid mountain slopes AF can be practiced on a whole farm as around Mt. Kilimanjaro (Chagga system) and Mt. Kenya (Grevillea system). In the drylands AF is rarely practiced on whole farms (except under parkland systems in the Sahel). It is more common for trees to be used in various productive niches within a farm. AF is mainly applicable to small-scale land users and in small-to large-scale tea / coffee plantations.

Resilience to climate variability: AF is tolerant to climate variability. AF systems are characterised by creating their own micro-climates, and buffering extremes (excessive storms or dry and hot periods). AF is recognised as a greenhouse gas mitigation strategy through its ability to sequester carbon biologically. The adaptation and mitigation potential depends on the AF system applied.

Main benefits: Agroforestry systems have great potential to diversify food and income sources, improve land productivity and to stop and reverse land degradation via their ability to provide a favourable micro-climate, provide permanent cover, improve organic carbon content, improve soil structure, increase infiltration, and to enhance fertility and biological activity of soils.

Adoption and upscaling: There is a lack of quantitative and predictive understanding about traditional and innovative agroforestry practices and their importance in order to make them more adoptable. Long term field research / monitoring are needed because of the complex nature of tree / crop systems.

Development issues addressed	
Preventing / reversing land degradation	+++
Maintaining and improving food security	+++
Reducing rural poverty	+++
Creating rural employment	+
Supporting gender equity / marginalised groups	++
Improving crop production	++
Improving fodder production	++
Improving wood / fibre production	++
Improving non wood forest production	+
Preserving biodiversity	+++
Improving soil resources (OM, nutrients)	+++
Improving of water resources	++
Improving water productivity	+++
Natural disaster prevention / mitigation	+++
Climate change mitigation / adaptation	+++

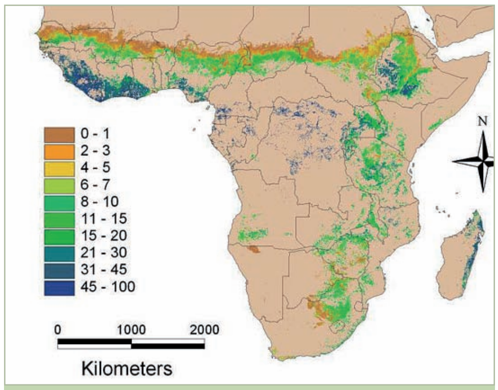
Climate change mitigation	
Potential for C Sequestration (tonnes/ha/year)	0.3 - 6.5*
C Sequestration: above ground	++
C Sequestration: below ground	++

Climate change adaptation	
Resilience to extreme dry conditions	++
Resilience to variable rainfall	+++
Resilience to extreme rain and wind storms	++
Resilience to rising temperatures and evaporation rates	++
Reducing risk of production failure	++

** for a duration of the first 20-30 years of changed land use management, depending on the selected tree species (Source: Nair et al., 2009)*

Origin and spread

Origin: AF encompasses many traditional land-use systems such as home gardens, boundary tree planting, shifting cultivation and bush fallow systems, contour cropping. AF is traditional and was 'rediscovered' in 1978 when the name 'agroforestry' was coined. Since then it has been promoted by projects and through land user's initiative. Alley cropping was conceived in the late 1970s by research to eliminate the need for a fallow period in the humid and subhumid tropics to replenish soil fertility.
Mainly applied in: Burkina Faso, Ethiopia, Guinea, Kenya, Lesotho, Malawi, Mozambique, Nigeria, Niger, South Africa, Tanzania, Togo, Uganda, Zambia, Zimbabwe: however all countries in SSA practise one form or another of AF. What differs is the extent, and the forms of AF practiced in these countries.



Tree cover on agricultural land in SSA
(Source: Zomer et al., 2009)

Principles and types

The factors influencing the performance of AF are crop, livestock and tree types and mixtures, germplasm, number and distribution of trees, age of trees, management of crops, livestock and trees, and the climate.
Agroforestry parkland systems are mainly cropland areas with dispersed trees (often indigenous). Among the characteristics of traditional agroforestry parklands are the diversity of tree species they contain and the variety of products and uses (including fruits, fodder, etc.). They generate and provide favourable micro-climates (through shade especially) and buffer extreme conditions (through acting as windbreaks). Parklands are found primarily in the semi-arid and subhumid zones of West Africa. *Faidherbia albida* / cereal systems are predominating throughout the Sahelian zone (e.g. 5 million ha in Niger) and in some parts of East Africa. For many local populations these systems are very important for food security, income generation and environmental protection.
Multistorey systems are defined as existing or planted stands of trees or shrubs that are managed as an upperstorey of woody plants and one to several understoreys of woody and non-woody plants that are grown for a variety of products. The purpose is (a) to use different layers and improve crop diversity by growing mixed but compatible crops of different heights in the same area; (b) protect soils and provide a favourable micro-climate; (c) improve soil quality by increasing utilisation and cycling of nutrients and maintaining or increasing soil organic matter and (d) increase carbon storage in plant biomass and soil. The Chagga homegardens of Tanzania, which integrate more than 100 plant species, provide a classic example of a multistorey AF system.
Fodder banks: Trees and shrubs with palatable leaves and / or pods are attractive to farmers as feed supplements for their livestock because they require little or no cash for inputs: they can be grown on boundaries as trees (often pollarded to reduce competition) or as hedges. They effectively do not compete for land as they are grown along boundaries, pathways - and along the contour to curb soil erosion. Managing fodder shrubs requires multiple skills including raising seedlings in a nursery, pruning trees, and feeding the leaves. This is a constraint to rapid spread of the technology. Nevertheless, over the past 10 years, about 200,000 farmers in Kenya, Uganda, Rwanda, and northern Tanzania have planted fodder shrubs, mostly to feed dairy cows.
Improved fallows consist of planted woody species in order to restore fertility within a short time. Traditionally fallows take several years. Natural vegetation is slow in restoring soil productivity. By contrast, fast growing leguminous trees and bushes - if correctly identified and selected - can enhance soil fertility by bringing up nutrients from lower soil layers, litter fall and nitrogen fixation. Improved fallows are one of the most promising agroforestry technologies in the subhumid and humid tropics and have shown great potential for adoption in southern and eastern Africa in recent years.
Windbreaks / shelterbelts are barriers of trees and shrubs that protect against damaging wind. They are used to reduce wind velocity, protect growing plants (crops and forage), improve micro-environments to enhance plant growth, delineate field boundaries, and increase carbon storage.

Top: Off-season onion gardens (background) in a parkland system, Burkina Faso. (Christoph Studer)
Middle: Intercropping of 4 different plant species, Rwanda. (Hanspeter Liniger)
Bottom: Agroforestry with grevilla trees, coffee, tea on steep mountain slopes, Kenya. (Hanspeter Linigier)

Applicability

Land degradation addressed

Chemical soil deterioration: declining soil fertility and organic matter content (due to continuous cropping and few inputs)
Erosion by water and wind: loss of fertile topsoil
Physical soil deterioration: compaction, sealing and crusting
Water degradation: namely high water losses by non-productive surface evaporation, extreme heavy events causing runoff and erosion

Land use

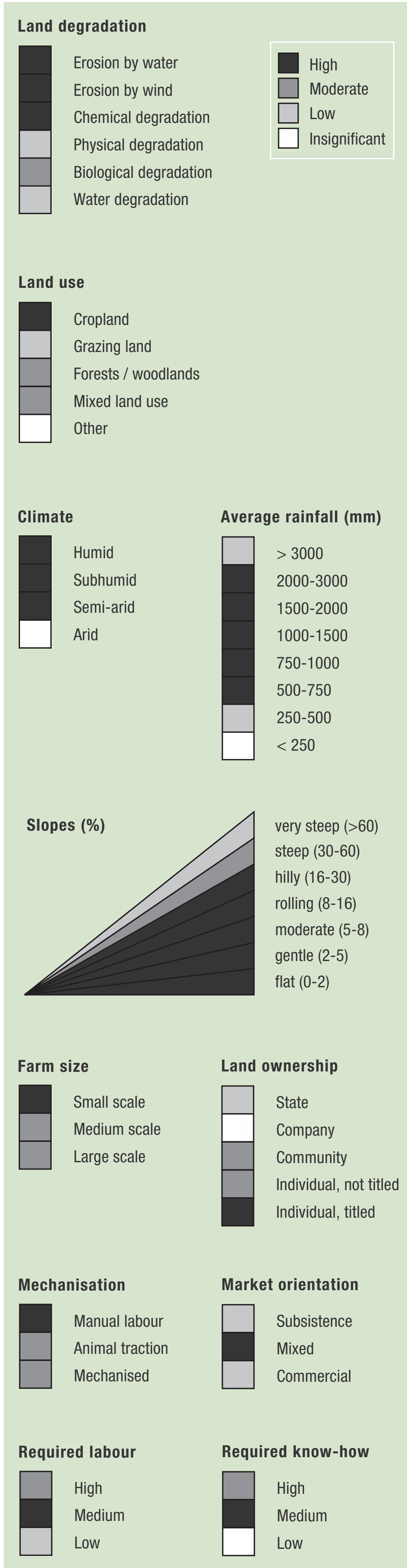
AF is suitable for all types of cropping systems where woody and non-woody species can be mixed. It is suitable for dry areas suffering from strong winds and wind erosion and low soil fertility (parkland systems, alley cropping and / or shelterbelts). Multistorey systems are suitable for areas with excessive rainfall causing erosion by water, soil compaction, expensive inputs especially fertilizers, pest and diseases.
Unsuitable for dry areas in situations where a lack of land (small farming units) makes AF systems such as parklands and improved fallows unsuitable. In more humid regions AF can be practiced on very small land parcels (e.g. Chagga homegardens; other multistorey systems). Unclear land and tree use rights are not favourable for the establishment of AF systems.

Ecological conditions

Climate: AF systems can be found in all kind of environments. Systems with low tree densities are more suitable in low rainfall areas and high density systems in high rainfall areas. AF in its diversity is suitable for a wide range of climates and AEZs. Parklands are not confined to specific AEZs and occur in various latitudes, but primarily in the semi-arid and subhumid zones of West Africa and in some parts of East Africa. Multistorey systems are more applicable in subhumid to humid environments or under irrigated systems, due to water requirements. Alley cropping and improved fallow have a wide range of applicability from semi-arid to humid.
Terrain and landscape: Suitable for all landforms and slopes: plains / plateaus as well as slopes and valley bottoms. Not suitable for high altitudes (higher than 2,000 – 2,500 m a.s.l) due to lower temperatures, negative impact of shade and a shorter growing season. AF is viable on steep land which otherwise is too steep for cropping: here AF can help building up terraces if trees are planted along the terrace risers.
Soils: No major limitations, AF is suitable for a wide range of soils. AF system can restore the soil fertility, where other land use systems have mined (depleted) soil nutrients.

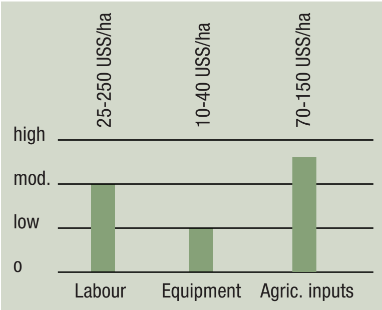
Socio-economic conditions

Farming system and level of mechanisation: Mainly applied on small-scale farms. However, it can be applied to all farm scales and conducted under different level of mechanisation (where trees are planted at low densities). In many countries women are the main actors in home gardening and food is mainly produced for subsistence.
Market orientation: Mainly applied in mixed systems (subsistence with some commercial). Can be applied in subsistence or commercial systems; access to markets is important to sell surplus production and for availability of inputs.
Land ownership and land use / water rights: Mostly applied on areas with individual land use rights and where land users have the rights to the trees they plant and tend. Communally owned land often lacks security of tenure and hence renders land users reluctant to practise and invest in agroforestry. Local regulations for the use of trees and crops are needed.
Skill / knowledge requirements: Medium to high and often part of a tradition, however selection of species suitable for different environments and purposes, as well as to minimise competition, needs know-how.
Labour requirements: Very variable, can be high for establishment – unless a system of protecting natural regeneration is used - but low for maintenance though some input needed for pollarding and pruning to reduce competition.

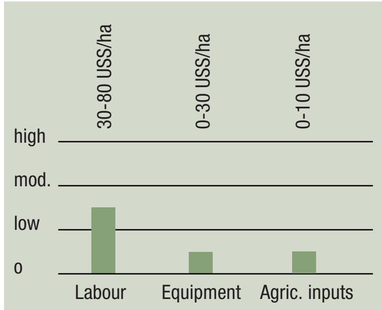


Economics

Establishment costs



Maintenance costs



Based on case studies from Ethiopia, Kenya and Togo (Source: WOCAT, 2009)

Establishment costs for agroforestry systems can vary a lot. Labour and agricultural inputs (seeds, seedlings, etc.) affect the establishment costs especially when linked to rainwater harvesting systems in drier areas.
Maintenance costs are relatively low.

Production benefits

	Yield without SLM (t/ha)	Yield with SLM (t/ha)	Yield gain (%)
Maize (Malawi)	0.7	1.5-2.0	110-190%

(Source: Malawi Agroforestry Extension Project; in Woodfine, 2009)

Comments: Crop yields can increase under an agroforestry system, however, AF does not lead in every case to an increase in crop production; depending on the type of system, the aggregate yield may improve as the products gained from the trees / shrubs compensate for any loss of crop yield.

Benefit-Cost ratio

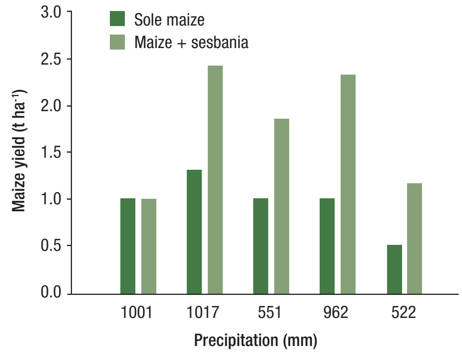
AF systems	short term	long term	quantitative
Parkland systems	–/+	+/++	No data available
Multistorey	+/++	+/++	
Alley cropping	+	++	
Improved fallow	++	+++	
Overall	+	++	

– – negative; – slightly negative; –/+ neutral; + slightly positive; ++ positive; +++ very positive
(Source: WOCAT, 2009)

Comments: Available benefit-cost analyses all point to the economic profitability of integrating trees within crop fields (particularly multipurpose tree species). Analyses have mostly only taken direct use values into account, because indirect use values, such as environmental functions, and non-use values such as cultural and religious functions are more difficult to evaluate. Furthermore, benefit-cost estimates are complicated by the many sources of annual variation in factors governing tree and crop production and tree-crop interactions.

Impact over different temporal scales is an issue that is especially relevant to agroforestry. Low-income land users more readily adopt agroforestry practices with short term benefits such as short term improved fallows (enriched with N-fixing bush / tree species) and multistorey systems.

Example: Malawi
Modeled maize grain yields in improved fallow rotations in Makoka, Malawi as a function of growing season precipitation.



(Source: Chirwa, 2003 in Verchot et al., 2007)

Example: Kitui district, Kenya
Within a study conducted in Kitui district, Kenya it was determined whether growing Melia volkensii trees in croplands was cost effective or not. The value of timber products gained with that of the crop value lost due to competition over an 11-year rotation were compared. Costs for seed, cultivation, tree planting stock or labour were not taken into account, which would increase the surplus of cash from the tree products because in recent years, crop failure has occured 50% of the time. It was shown that at the end of the rotation, the accumulated income from tree products exceeded the accumulated value of crop yield lost through competition by US$ 10 or 42% during average years and US$ 22 or 180% with the assumption of 50% crop failure due to drought. (In this district of Kenya, on average six of the 16 cropping seasons have failed) (Ong et al., 1999 in Verchot et al., 2007).

Example: Kenya, Uganda, Rwanda, and northern Tanzania
In the highlands of East Africa farmers with 500 calliandra shrubs increased their net income by between $US 62 to 122 depending on whether they used shrubs as a substitute, or as supplement, and depending on where they are located. Fodder shrubs are very attractive to farmers because they require little or no cash, nor do they require farmers to take land out of production for food or other crops (Franzel and Wambugu, 2007).

Impacts

Benefits	Land users / community level	Watershed / landscape level	National / global level
Production	+++ crop diversification ++ higher combined yields (trees, crops and livestock) ++ provide products year around	+++ reduced risk and loss of production ++ access to clean drinking water ++ reliable fuel wood supply	+++ improved food and water security
Economic	++ generate additional cash income	+++ less damage to off-site infrastructure + creation of employment + stimulation of economic growth	+++ improved livelihood and well-being
Ecological	+++ improved soil cover +++ reduced soil erosion (by water / wind) +++ favourable changes in micro-climatic conditions (e.g. shade trees (can reduce temperature extremes by approximately 5°C, windbreaks) ++ improve soil fertility and biological activity ++ improve organic carbon content (above and below ground) ++ more effective use of available water ++ enhanced biodiversity and soil life ++ improve soil structure + biocontrol of pests and diseases	+++ reduced degradation and sedimentation ++ increased water availability ++ improved water quality ++ intact ecosystem	+++ increased resilience to climate change +++ enhanced biodiversity ++ arresting and reversing land degradation
Socio-cultural	++ improved conservation / erosion knowledge ++ multipurpose tree, meeting various needs ++ reduces pressure on forests + community institution strengthening + social services (as boundary markers) + aesthetic value	++ increased awareness for environmental health ++ reduced conflicts due to reduced negative off-site impacts ++ attractive landscape ++ reduced deforestation	+++ protecting natural and national resources for the next generations (heritage)

	Constraints	How to overcome
Production	• Systems produce multiple products under specific conditions: some single products can suffer due to competition	➜ minimise competition and emphasise the overall production
Economic	• Labour and time consuming • High input demand • Reduced flexibility to changing markets related to tree products	➜ participation of all family members ➜ maximum use of locally available inputs: including indigenous tree seedbanks
Ecological	• Competition between trees (parkland, windbreaks, alley cropping) and crops for light, water and nutrients • Interception of rain by canopy • Loss of land for non-woody crops • Depleting groundwater (when scarce groundwater) • Dry periods result in low seedling survival rates • Timber susceptible to pest attack	➜ species selection and canopy management for reducing above and below ground competition (e.g. pruning of tree branches, periodic root pruning) ➜ with water harvesting and moisture management techniques, the technology could spread to lower rainfall areas ➜ increase the productivity of land per unit area, regular pruning of woody bush and trees esp. during the crop growing period ➜ species selection ➜ supplement with water harvesting and moisture management techniques ➜ species selection, integrated pest management, breeding of more pest tolerant varieties
Socio-cultural	• Forest policies hindering planting, use and ownership of trees • Physical and social barriers to smallholder participation in markets • The overall lack of information at all levels on markets for agroforestry products • Seedling availability and survival low	➜ e.g. charcoal policy reform and rights to trees; contract fuelwood schemes ➜ novel market information systems (e.g. per cell phones); facilitating and capacity building of farmer and farm forest associations ➜ collaboration between the private sector, research and extension ➜ small-scale nursery enterprises encourage local seed collection

Adoption and upscaling

Adoption rate

The complex management requirements of agroforestry (AF) may limit its adoption. Agroforestry systems, such as improved fallows, found widespread acceptance and adoption by smallholder farmers in Southern Africa (e.g. Zambia). In regions such as the highlands of East Africa, AF systems have spread with very little or no support from the outside, as land users value trees for multiple purposes and have strong motivation to plant and maintain good tree cover. 'Fertilizer tree species' (making nutrients available from deeper soil layers) tend to be adopted to a greater extent by the poorest families in the villages, which is unusual for agricultural innovations. Recently, with improved rainfall, secured rights to trees and project support, there has been a massive increase in parkland systems in the West African Sahel.

Upscaling

Parklands, for example, were developed by farmers over many generations to diversify production for subsistence, and for income generation, as well as to minimise environmental risks related to the high climatic variability in the region. This knowledge and tradition needs to be tapped and built upon in order to upscale AF. Understanding the system and how it works in different environments is also crucial. A knowledge system is needed that documents experiences and facilitates exchange between practitioners and scientists from different countries, and stimulates better understanding of the processes behind upscaling. Land users need more information and training to be able to adopt and implement AF systems suitable for their specific environmental conditions, as compared to other agricultural activities. This limits the spread of some AF techniques. Extension strategies, including field schools, exchange visits and farmer training, are effective ways of disseminating information.

Incentives for adoption

Both ecological and social factors are simultaneously important in motivating land users to grow trees on their farms. Land users as observed do accept yield losses provided the new intervention results in a clear return on investment. In the traditional parklands of West Africa, dense shading by shea nut trees (*Vitellaria paradoxa*) and *néré* (*Parkia biglobosa*), which reduce millet yield by 50–80% are used because of the high economic returns from marketable tree products. Markets for multipurpose tree products are crucial for the adoption of AF on a scale to have meaningful economic, social and environmental impacts. Land tenure reforms and established systems of payment for ecosystems services (PES) will encourage land ownership and stimulate the development of plantations (both forest and AF parklands). A stronger AF focus in agricultural policy and extension services and the promotion of markets and improved processing of AF products will encourage the adoption. Incentives provided are often in relation to building up tree nurseries at the village level.

Enabling environment: key factors for adoption	
Inputs, material incentives, credits	+
Training and education	++
Land tenure, secure land use rights	++
Access to markets (niche markets and high value products)	++
Research	++
Infrastructure	+

Example: Kenya, Uganda, Rwanda, and northern Tanzania

The spread of fodder shrubs in East Africa has been substantial. By 2006, about 10 years after the dissemination began, 224 organisations across Kenya, Uganda, Rwanda, and northern Tanzania were promoting fodder shrubs, and over 200,000 farmers had planted them, even though the number of shrubs per farm was still well below the number needed to feed a single dairy cow. The reason for the still rather low number of shrubs is that many farmers adopt incrementally - they first want to see how it performs, and many farmers 'partially adopt' applying several different strategies for providing fodder supplements to ensure better risk management. Due to the information-intensive nature of the technology, it does not spread easily on its own and thus requires outside facilitation. Considerable investments are required to reach other dairy farmers and sustain the uptake process (Franzel and Wambugu, 2007).

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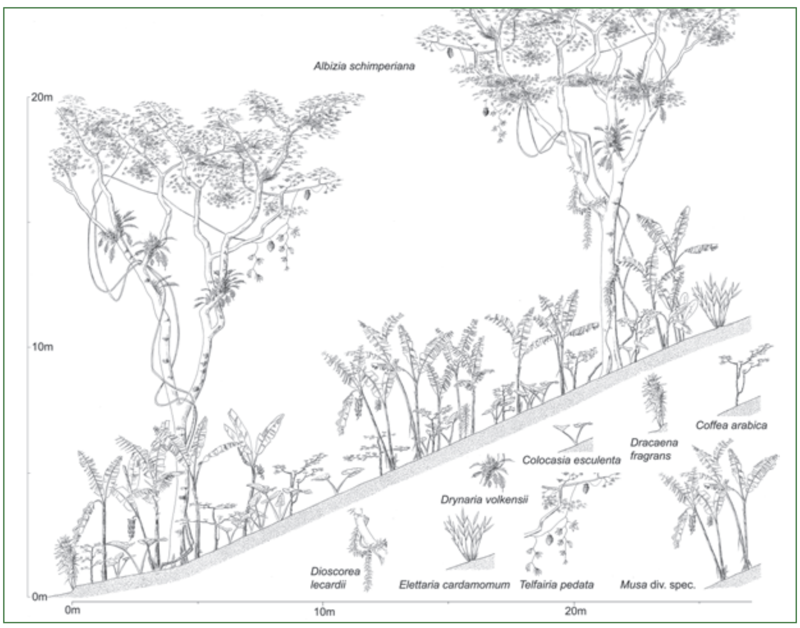
CHAGGA HOMEGARDENS - TANZANIA

The Chagga homegardens are traditional, densely planted 'banana forests' with a scattered upper tree layer. The complex multicropping system evolved over several centuries through a gradual transformation of the natural forest on the footslopes of Kilimanjaro. A Chagga homegarden has an average size of 0.68 ha and integrates numerous multipurpose trees and shrubs with food crops, and stall-fed animals, without a specific spatial arrangement. However, vertically, the following 4 stories / canopies can be distinguished: (1) food crops: taro, beans, vegetables and fodder herbs / grasses; (2) coffee: 500-1,400 plants/ha; (3) banana: primary crop; 50% cover; 330-1,200 clumps/ha; and (4) trees, such as *Cordia abyssinica*, *Albizia schimperiana* and *Grevillea robusta*. The trees provide shade for coffee, act as live fences, provide medicines, firewood, fodder, mulching material, bee forage; and some have pesticidal properties (e.g. *Rauwolfia caffra*).

This multilayer system maximises the use of limited land in a highly populated area, making sustained production possible with a minimum of external inputs, minimises risk (less production failure, increased resistance against droughts and pests) and ensures at the same time environmental protection. The large species diversity provides both subsistence and cash crops.

Parts of the homegarden area are irrigated and drained by a network of over 1,000 canals and furrows tapping runoff from the montane forest. However, many systems are now in disrepair. Starting in the 1930s when coffee took more space from the food production, it became necessary to expand food production to the lowlands. Today, the Chagga highland homegarden works only in combination with a lowland field where maize, millet, beans, sunflower and groundnuts are grown to ensure food security.



SLM measure	Management and vegetative
SLM group	Agroforestry
Land use type	Mixed (Agroforestry)
Degradation addressed	Nutrient depletion; Loss of topsoil
Stage of intervention	Prevention
Tolerance to climate change	Tolerant to climatic extremes: the system has a high buffer capacity (micro-climate, biodiversity, irrigation)

Establishment activities

1. Transforming the native forest: trees that provided fodder, fuel, fruits, medicines, shade, timber, bee forage, anti-pest properties are retained while the less useful species are eliminated.
2. Introduction of new fruit and timber tree species, such as avocado, mango, *Grevillea robusta*, *Persea americana.*
3. Planting crop species (banana, coffee, taro, beans, vegetables).
4. Establishment of irrigation / drainage channels.
5. Terracing or building of bunds in steep places.

Spatial arrangement of components is irregular and appears haphazard with the trees / shrubs and food crops intimately mixed.

Maintenance / recurrent activities

1. Planting, tending and harvesting of bananas, taro, yams (all year round).
2. Opening up the canopy to ensure better fruiting of the coffee.
3. Spacing out the banana stools.
4. Manuring crops (using dung from the stall-fed livestock and compost).
5. Lopping fodder trees / shrubs.
6. Pruning and spraying against coffee berry disease and leaf rust.
7. Maintaining irrigation furrows.
8. Coffee harvest (August-January).
9. Tending and milking the stall-fed cows (typically only one cow).
10. Mulching, terrace maintenance (soil erosion prevention in general).

All operations are performed manually.

Labour requirements

For establishment: medium
For maintenance: medium

Knowledge requirements

For advisors: medium to high
For land users: medium to high

Photo 1: Chagga homegardens with the snow-capped peak of Mt. Kilimanjaro in the background. (Hanspeter Liniger)
Profile: Typical chagga homegarden on a 45% slope at 1,400 m a.s.l. with 4 vegetation layers: open light upper canopy with *Albizia schimperiana* (up to 20 m high); upper shrub layer with banana (4-6 m); a lower shrub layer with coffee (1.5-2 m) and food crops such as taro (< 1.5 m) (Hemp A., Hemp C. 2009)

Case study area: Mt. Kilimanjaro Region, Tanzania

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	na
Equipment	na
Agricultural inputs	na
TOTAL	**na**

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	300
Equipment (axes, hoes, pangas)	45
Agricultural inputs	100
TOTAL	**445**
% of costs borne by land users	100%

Remarks: Chagga homegardens are traditional systems which evolved over centuries through a gradual transformation of the natural forest into agroforestry gardens. Establishment of new gardens is not possible due to land shortage.

Benefit-cost ratio

Inputs	short term	long term
Establishment	na	na
Maintenance	positive	very positive

Adoption

Locally well adopted traditional land use system, covering an area of approximately 1,200 km²; further spread at local level is not possible due to land shortage. Migration of young people to urban areas leads to labour shortages and disrupts intergenerational knowledge transmission, required for the successful management and perpetuation of the homegardens.

Ecological conditions

- Climate: subhumid (tropical montane; bimodal: long rains in March-May, short rains in Nov-Dec)
- Average annual rainfall: 1,000-2,000 mm (depending on slope orientation and altitude)
- Soil parameters: fertile volcanic soils with a high base saturation and cation exchange capacity
- Slopes: hilly to steep (16 - 60%)
- Landform: Mountain slopes, orientation south / south-east
- Altitude: 1,000-1,800 m a.s.l.

Socio-economic conditions

- Size of land per household: 1-2 ha (2-3 separate plots)
- Type of land user: poor small-scale farmers
- Population density: 650 persons/km²
- Land ownership: individual, traditional clan regulations (land cannot be sold to outsiders)
- Land use rights: individual
- Market orientation: mixed (subsistence and commercial)
- Level of mechanisation: manual labour

Production / economic benefits

+++ Continuous and diversified production: 185 kg beans/ha; 410 kg coffee/ha; 400 bunches of banana/ha; ca. 30 kg honey/ha
+++ Reduced risk of crop failure
++ Increased fuelwood production 1.5-3 m³/ha/year
++ Valuable gene pool (for breeding programmes to improve crop varieties for multistorey cropping systems)
++ Increased labour efficiency

Ecological benefits

+++ Improved continuous ground cover
+++ Improved micro-climate
+++ Improved soil conservation and reduced soil loss
+++ High biodiversity and genetic variability (over 500 plant species including 400 non-cultivated plants)
++ High pest resistance

Socio-cultural benefits

+++ Improved food security
+++ Improved health
+++ Preservation of traditional knowledge

Weaknesses ➜ and how to overcome

– Productivity of Chagga homegardens is not optimal ➜ (1) Replace the less productive trees / shrubs with fast growing nitrogen fixing species (2) improve animal husbandry (e.g. to increase lactation period); (3) improve apiculture; (4) introduce new crop varieties using the gene pool developed by natural and farmer selection; (5) use fertilisers; (6) improve coffee production: certified production (organic, fair trade) to fetch higher prices; (7) replace old coffee plants with new ones; (8) integrated pest management; (9) facilitate access to capital for farm investments; (10) improve erosion control (terraces and bunds); (11) include productive fruit trees; (12) improve advisory services.
– Water management causes nutrient loss in the gardens and water shortages on the lower slopes ➜ improve efficiency of furrows: Install pipes and surfacing by cement, protect river banks from cultivation.
– High demand of wood, low coffee prices and the introduction of sun-tolerant coffee varieties endanger the homegardens ➜ incentive-based tree planting in gardens to reduce the pressure on the forest.

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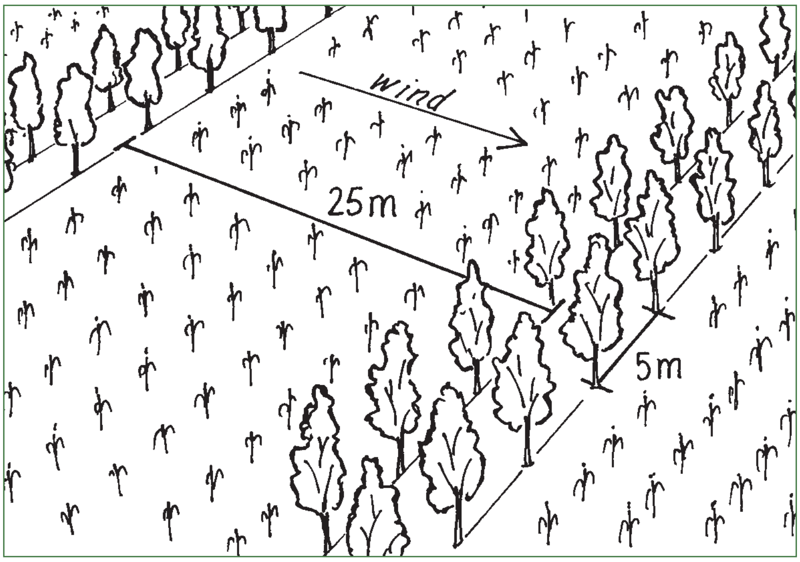
SHELTERBELTS - TOGO

On the vast denuded plains of Pays Kabyé in northern Togo, barriers of leguminous trees (e.g. *Cassia siamea* or *spectabilis*; a medium sized tree growing between 10-20 m tall; *Albizzia procera*, *Leucaena leucocephala*) and shrubs (*Cajanus cajan, Erythrina variegate*) are established between fields cultivated with annual crops such as maize. The shelterbelts provide a good microclimate and protect the crops against the counterproductive effects of wind speed such as wind erosion, soil moisture loss through evaporation and physical damage to crops.

The shelterbelts' effectiveness depends on their permeability, their spacing and the direction of planting in relation to the wind direction: A proportion of 40-50% of holes (openings, void) in relation to the total surface of the shelterbelt is desirable, and establishment of tree rows perpendicularly to the main wind direction is most effective. In order to reduce lateral turbulence the windbreaks need to reach a length of minimum 10 times their height. Shelterbelts protect 15-25 times their height on the leeward and 1-2 their height on the windward side. If the area to be protected is large, several windbreaks need to be established.

The denser the shelterbelts are, the better the windbreaking effect, but the higher the competition with crops for nutrients, light and water. Frequent pruning helps to avoid too much competition and provides fuelwood. In case leguminous tree species are used, soil properties can be improved through nitrogen fixation and the provision of organic matter (leaves).



SLM measure	Vegetative
SLM group	Agroforestry
Land use type	Cropland / mixed land
Degradation addressed	Wind erosion, Aridification
Stage of intervention	Prevention and mitigation
Tolerance to climate change	No data

Establishment activities

1. Determine the area to be protected and alignment of shelterbelts (1,2, or 3 lines of trees per row); rows to be established perpendicular to main wind direction; spacing between rows: 20-25m).
2. Establish plant nursery.
3. Dig planting pits at a spacing of 2-3 meters.
4. Planting of seedlings (when conditions are favourable).
5. Regular irrigation of young tree seedlings after plantation.
6. Weeding.
7. Reduce density to a spacing 5 m between trees.

All activities carried out during rainy season, using hand tools such as hoe, machete and measuring tape. Establishment takes 36 months.

Maintenance / recurrent activities

1. Weeding (according to necessity / speed of regrowth).
2. Pruning to avoid shading effect on crops.

Labour requirements

For establishment: high
For maintenance: moderate

Knowledge requirements

For advisors: high
For land users: moderate

Photo 1: A windbreak with two or three tree lines planted 5 m apart established between fields of annual crops. (Idrissou Bouraima)
Technical drawing: Spacing between windbreak rows is 20-25 m. The row of windbreak can be of a single tree line, of double tree lines, etc. depending on wind speed and scope of protection. The in between tree line spacing is 5 m. Plant density can range from 100 – 200 plants/ha depending on the number of tree lines planted within a windbreak. (Mats Gurtner)

Case study area: Tchitchao, Kara, Togo

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	200
Equipment	86
Agricultural inputs	90
TOTAL	**376**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	139
Equipment	
Agricultural Inputs	23
TOTAL	**162**
% of costs borne by land users	100%

Remarks: The monetary costs include the purchase of seeds, cuttings or nursery plants and labour for the preparation and planting. In certain circumstances, it is necessary to protect young trees against browsing and other damage.

Benefit-cost ratio

Inputs	short term	long term
Establishment	positive	positive
Maintenance	positive	very positive

Ecological conditions

- Climate: subhumid
- Average annual rainfall: 1,000-1,500 mm
- Soil parameters: medium to good drainage; shallow, sandy-loamy soils; medium soil organic matter
- Slope: gentle (2-5%)
- Landform: footslopes, plateaus / plains, hill slopes
- Altitude: 100-500 m a.s.l.

Socio-economic conditions

- Size of land per household: 1-2 ha
- Type of land user: small-scale farmers, relatively rich (about 1.5% of land users). Windbreak technology is little known by most farmers
- Population density: 300 persons per km^2 in the region
- Land ownership: individual, titled
- Land use rights: individual
- Level of mechanisation: no data
- Market orientation: subsistence and commercial

Production / economic benefits

++ Increased income from agriculture
++ Increased wood production and forest products (fruits)
++ Increased crop yield

Ecological benefits

++ Reduced wind speed
++ Reduced loss of topsoil (through wind erosion)
++ Reduced loss of soil moisture (through evaporation)

Socio-cultural benefits

++ Increased conservation / erosion knowledge

Socio-cultural benefits

++ Reduced off-site deposition of wind sediments

Weaknesses ➜ and how to overcome

- Reduced area for cultivation of crops ➜ establish the minimum of shelterbelts necessary for optimal protection.
- Reduced crop yields alongside shelterbelts (competition for nutrients, light, water) ➜ avoid dense planting of trees and shrubs; frequently prune the trees.
- Shelterbelts provide habitat for vermins / pests (rats, insects) ➜ frequently hunt these animals.
- Increased labour inputs.

Adoption

100% of the families who have implemented shelterbelts in the case study area have done it without any external support apart from technical advice. However, there is no growing trend of spontaneous adoption in the region since the windbreak technology is little known by most farmers.

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GREVILLEA AGROFORESTRY SYSTEM - KENYA

While *Grevillea robusta* (the 'silky oak', an Australian native) was originally introduced from India to East Africa as a shade tree for tea and coffee estates, it is now more commonly used in small-scale farming areas, especially in association with annual crops (maize / beans). There are three major forms of grevillea agroforestry systems: (1) planting along farm boundaries; (2) scattered grevillea trees on cropland - resembling open forests with multi-storey layers; (3) 'alley cropping' on terraces. Boundary planting is the most common form and is described in this case study.

Grevillea can be easily established and is relatively free of pests and diseases. The trees are managed through periodic pollarding – the pruning of side branches while maintaining the trunk – to reduce competition with crops. Competition is little in any case, and can be further reduced by digging a small trench around the trees, thus cutting the superficial roots.

Grevillea is planted for a number of purposes, including marking property boundaries, supplying fuelwood and building materials (pruning of side branches which rapidly regrow), providing shade and for ornamental value. Simultaneously it increases organic matter, provides mulching materials to improve ground cover, reduces wind speed, and encourages nutrient recycling due to its deep rooting. It can be planted over a wide range of agroecological zones and from sea level up to 2,000 metres. It is ideally suited to intensive areas of small-scale mixed farming. To effectively combat soil erosion problems on slopes, grevillea planting must be combined with additional measures such as *fanya juu* and bench terraces, grass strips and other vegetative and agronomic measures.

SLM measure	Vegetative
SLM group	Agroforestry
Land use type	Mixed (crops and trees)
Degradation addressed	Soil moisture problem; Fertility decline, reduced organic matter content; Loss of topsoil through water erosion
Stage of intervention	Mitigation
Tolerance to climate change	High tolerance to change of temperature and rainfall – Grevillea grows under a high range of climates

Establishment activities

1. Dig planting pits (before rainy seasons).
2. Purchase seedlings from nurseries or collection of wildings (naturally generated seedlings).
3. Plant seedlings (at onset of rains), initial spacing ca. 1 m, later thinned to 1.5 – 3 m.

Maintenance / recurrent activities

1. Weeding around seedlings when necessary (rainy season).
2. Pruning as necessary; pruned branches are dried and used for fuelwood (annually).
3. Pollarding (pruning of side branches; ensures large and straight tree trunks): annually, after crop harvest.
4. Root pruning: dig a trench (60 cm from tree, 25 cm deep) and cut the shallow roots to reduce competition with annual crops every four years.
5. Felling some trees to reduce density as they grow bigger (during dry season).
6. Replanting when trees are harvested for timber.

All activities carried out by manual labour using machetes (panga), hoes and handsaws.

Labour requirements

For establishment: moderate
For maintenance: moderate

Knowledge requirements

For advisors: moderate
For land users: low

Photo 1: Boundary planting of grevillea trees between smallholder plots used for cultivation of maize and beans.
Photo 2: Detailed view of a dense row of grevillea trees.
Photo 3: Scattered grevillea trees planted as a shade tree in a coffee plantation. (All photos by Hanspeter Liniger)

Case study area: Kiawanja, Nembure division, Embu, Kenya

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	25
Equipment	10
Agricultural inputs	125
TOTAL	**160**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	65
Equipment	0
Agricultural inputs	25
TOTAL	**90**
% of costs borne by land users	100%

Remarks: Boundary planting is the basis of costing (assuming average plot size of 25 m by 25 m and an average spacing of 1 m between trees = 1,000 trees/ha). 1 person plants 50 trees in one day. The labour required for management (pruning and pollarding) of established trees is high. Seedling purchase price is also high, but this can be reduced by collecting wildings (seedlings growing in the wild) and establishing personal or group nurseries.

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	very positive
Maintenance	slightly positive	very positive

Adoption

All land users of the catchment (totally 120 families) have accepted the technology spontaneously.

Ecological conditions

- Climate: subhumid
- Average annual rainfall: 1,000-1,500 mm
- Soil parameters: good drainage, deep well drained nitosols; soil organic matter mostly low and partly medium
- Slope: mostly rolling to hilly (8-30%), partly steeper
- Landform: ridges, mountain / hill slopes; also foot slopes / valleys
- Altitude: 1,000 – 1,500 m a.s.l.

Socio-economic conditions

- Size of land per household: mainly 1-2 ha, partly <1 ha
- Type of land user: mainly small-scale farmers
- Population density: > 500 persons/km^2
- Land ownership: individual titled
- Land use rights: individual
- Level of mechanisation: manual labour
- Market orientation: mixed (subsistence and commercial): marketed products include: grevillea timber, coffee, macademia nuts and milk

Production / economic benefits

+++ Increased wood production (for timber and fuelwood)
++ Increased farm income
+ Increased fodder production (leaves used as fodder during dry season)
+ Increased crop yield (through mulching and nutrient pumping)

Ecological benefits

+++ Reduced wind velocity (affecting crops / homesteads)
++ Improved soil cover (mulch and canopy cover)
++ Improved micro-climate
++ Increased soil fertility and organic matter (leaf litter, leaves used as cattle bedding; nutrient recycling)
++ Reduced soil loss
+ Increased soil moisture (mulching improves infiltration)
+ Biodiversity enhancement (bees, birds, etc.)

Socio-cultural benefits

++ Improved conservation / erosion knowledge (stakeholder interaction)
++ Improved housing (more timber available)

Off-site benefits

+++ Reduced deforestation (alternative source of fuel and timber)
++ Creation of employment (tree management and harvesting)
+ Reduced downstream flooding and siltation
+ Reduced river pollution (chemical contamination)
+ Increased stream flow in dry season

Weaknesses ➔ and how to overcome

- Seedlings and wildings not always readily available ➔ encourage local seed collection and setting up of group tree nurseries.
- Timber is susceptible to pests attack (weevils) ➔ timber treatment with appropriate chemicals; breeding of pest tolerant varieties.
- Livestock can damage young seedlings ➔ protection by fencing.
- Dry periods result in low seedling survival rates: planting not possible in dry areas ➔ combine technology with water harvesting / moisture management techniques.
- Competition with crops ➔ regular pruning of side branches; dig a small trench around the trees, thus cutting the superficial roots.
- Limited efficiency of agroforestry system in combating soil erosion problems on slopes ➔ combine with agronomic and vegetative measures (e.g. contour ploughing, mulching, grass strips), and where necessary with structural measures (e.g. terraces, bunds and ditches).

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FARMER MANAGED NATURAL REGENERATION - NIGER

Farmer Managed Natural Regeneration (FMNR) is the systematic regeneration of living and sprouting stumps of indigenous vegetation which used to be slashed and burned in traditional field preparation. The naturally occurring seedlings and / or sprouts are managed and protected by local farmers. Most suitable are species with deep roots that do not compete with crops and have good growth performance even during poor rainy seasons. In the case study area the three most valuable species – as perceived by land users – are *Faidherbia albida*; *Piliostigma reticulatum* and *Guiera senegalensis*.
The ideal density, when grown with cereal crops, is between 50 and 100 trees per hectare. For each stump, the tallest and straightest stems are selected and side branches removed to roughly half of the stem height. Excess shoots are then removed. Regular pruning of any unwanted new stems and side branches stimulates growth rates. Farmers are encouraged to leave 5 stems / shoots per tree, cutting one stem each year and letting another grow in its place. On removing a shoot, the cut leaves are left on the surface where they reduce erosion and are then eaten by termites, returning the nutrients to the soil. The remaining shoots continue to grow, providing a continuous supply of wood. From the first year, firewood is collected from trimmings. From the second year on, cut branches are thick enough to sell. A more intensive form of FMNR is to profit from every stump sprouting on the land. This option allows idle land to become a productive resource during an otherwise unproductive eight-month dry season.
FMNR is a simple, low-cost and multi-benefit method of re-vegetation, accessible to all farmers, and adapted to the needs of smallholders. It reduces dependency on external inputs, is easy to practice and provides multiple benefits to people, livestock, crops and the environment. Tree layout will need to be carefully considered if ploughs are used for cultivation.

SLM measure	Vegetative and management
SLM group	Agroforestry
Land use type	Mainly annual cropping
Degradation addressed	Deforestation; Wind erosion and sedimentation (increased wind speed, dust storms); Water deficiency; Sand dune movements
Stage of intervention	Mainly rehabilitation, partly mitigation
Tolerance to climate change	Tolerant to climatic extremes (e.g. droughts, temperature increase, rainfall decrease, etc.)

Establishment activities

1. Select 50 - 100 stumps per hectare for regrowth during the dry season.
2. Select the tallest and straightest stems and prune side branches to roughly half the height of the stem (using sharpened axe or machete and cutting upwards carefully).
3. Remove excess shoots, leave the cut leaves on the surface.
4. Prune any unwanted new stems and side branches (each 2-6 months).

All activities carried out manually.

Maintenance / recurrent activities

1. Cut one stem (per tree) each year and let another grow in its place.
2. Once the stems selected for growth are > 2 meters high, they can be pruned up to two thirds.
3. Prune any unwanted new stems and side branches (each 2-6 months).

All activities carried out manually.
Note: Farmers in different countries have developed a range of management practices which best suit their needs and thus differ from the present case study.

Labour requirements

For establishment: low
For maintenance: low

Knowledge requirements

For advisors: medium
For land users: medium

Photo 1: Mature FMNR system in Maradi, with millet and a tree density of around 150 trees/ha.
Photo 2: New tree sprouts in front of the farmer, harvested wood in the background. Note the proximity of the crop (millet) to the tree without detrimental effect.
Photo 3: Re-sprouting tree stumps and roots: the basis of FMNR.
Photo 4: Typical FMNR farm after harvest of millet.
Photo 5: After just one year the numerous stems are growing vigorously and straight. Ideally, one or two are harvested from the clump each year, always leaving new regrowth to replace them. (All photos by Tony Rinaudo)

Case study area: Maradi, Niger

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour: 2-3 person-days	6
Equipment / tools: see below	0
Agricultural inputs: none	0
TOTAL	**6**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour: 1-2 person-days	4
Equipment / tools: see below	0
Agricultural inputs: none	0
TOTAL	**4**
% of costs borne by land users	100%

Remarks: Main costs are in the form of labour. One man could prepare one hectare in 1–3 days, depending on tree density (labour is undertaken by the farm owner and rarely through paid labour). No inputs used; no extra tools needed, tools are available on-farm (hoe, axe, machete etc). Maintenance costs depend on tree density also and could require 1–2 days/year/ha.

Benefit-cost ratio

Inputs	short term	long term
Establishment	positive	very positive
Maintenance	positive	very positive

Remarks: Annual income from selling wood: US$ 140 (from the 6th year after implementation). By some estimates, total benefit per hectare (incl. wood sales, increased crop yield, increased livestock productivity, wild foods and medicines etc.) are in the order of US$ 200/ha, compared to an investment in labour US$ 10-15.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 150–500 mm (variable)
- Soil parameters: low fertility, very low soil depth, drainage and organic matter content
- Slope: mainly flat, partly undulating
- Landform: mainly plains
- Altitude: 200–300 m a.s.l.

Socio-economic conditions

- Size of land per household: 1–5 ha (average production area)
- Type of land user: small-scale; very poor and poor land users
- Population density: 11 persons/km^2
- Land ownership: individual, generally untitled
- Land use rights: individual
- Level of mechanisation: mainly manual labour, partly animal traction
- Market orientation: mixed (subsistence and commercial)
- FMNR can be practiced by any farmer, even the poorest. No external

Production / economic benefits

+++ Increased wood production (production value increased by 57%)
+++ Increased income
+++ Increased crop production (at least doubled)
++ Reduced workload: no annual clearing / burning of trees
++ Increased livestock production (nutritious pods as fodder)

Ecological benefits

+++ Increased soil cover and increased biomass: increased tree density on farmland (from 30 to 45 trees/ha average)
+++ Windbreak effect: deposition of rich, wind blown silt; improved micro-climate
+++ Increased organic matter from leaf fall and trimmings
+++ Increased soil fertility (dung; livestock spends more time in fields with trees)
+++ Increased biodiversity; creation of habitat, food and shelter for predators of crop pests
+++ Increased drought-tolerance: regenerated trees are indigenous and generally have mature root systems

Socio-cultural benefits

++ Increased food security: edible leaves / fruits; bridge food shortages
+++ Improved quality of life: reduced wind speeds and dust; shade is available; barren landscape is returning to a natural savanna
+++ Increased disaster risk reduction: FMNR acts as an insurance policy

Off-site benefits

+++ Urban populations benefit from cheaper, sustained wood supply and reduced incidence of dust storms

Weaknesses ➜ and how to overcome

- Scarce presence of live tree stumps ➜ alternatively broadcast seeds of indigenous species (reduced short term benefits; high mortality rates).
- Cultural norms and values: 'a good farmer is a clean farmer' (= no trees) ➜ work with all stakeholders to change norms.
- Land (including trees) is treated as common property during dry season; damaging and removing trees on other people's land occurs ➜ create sense of ownership of trees: (1) encourage communities to develop rules that respect property; (2) local forestry authorities granting informal approval for farmers to be able to reap the benefits of their work.

Adoption

The technology has first been implemented in Maradi region, Niger in the early 1980's. Spread has been largely spontaneous, with minimal external assistance. The area covered today by trees from FMNR is estimated to be more than 50,000 km^2 in Niger.

Main contributors: Tony Rinaudo; World Vision, Melbourne; tonyrinaudo@worldvision.com.au; Dov Pasternak ICRISAT-WCA, Niamey, Niger; d.pasternak@icrisatne.ne
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PARKLAND AGROFORESTRY SYSTEM - BURKINA FASO

Parklands are the traditional agroforestry systems of semi-arid West Africa or Sahel where naturally growing, valuable trees are protected and nurtured on cropping and grazing lands. For the rural people in the Sahel, parkland trees are multipurpose: they are a grocery shop, a pharmacy and a silo at the same time. People rely on many locally cherished species to provide food and nutritional security for both human and livestock populations and to protect and enrich soils. Important tree species are baobab (*Adansonia digitata*), tamarind (*Tamarindus indica*), *Faidherbia albida*, shea nut or *karité* (*Vitellaria paradoxa*, see photo 1 below) and *néré* (*Parkia biglobosa*).

Crop production can be increased below and around the trees (especially under *Faidherbida albida*) due to the favourable micro-climate, accumulation of soil organic matter through litter fall, prunings and root decay in the predominantly sandy and poor soils.

Parkland management practices include: assisted tree regeneration (see also Farmer Managed Natural Regeneration, Niger); Tree planting (mostly in vicinity of family compounds); Improved fallows (under which economically useful and fertility-improving trees are planted before cropping is discontinued) and fire protection. Farmers commonly apply silvicultural techniques to increase production of parkland trees. These include seedling protection and fencing, watering, and the selection of vigorous shoots. Pruning is done to improve productivity of trees, reduce shade and enhance understorey crop performance and to produce fuelwood and fodder. It stimulates leaf regrowth, causes an additional foliation peak during the rainy season and depresses pod production. Coppicing and pollarding represent a way of limiting competition with intercrops and providing wood and other tree products in species with good vegetative growth.

SLM measure	Vegetative
SLM group	Agroforestry
Land use type	Mixed (crops and trees)
Degradation addressed	Desertification problem; Fertility decline, reduced organic matter content; Loss of topsoil through water erosion
Stage of intervention	Mitigation
Tolerance to climate change	Increased tolerance through the use of indigenous species

Establishment activities

1. Retaining saplings from natural regeneration or wildings before rainy seasons.
2. Planting improved material (early stage).
3. Grafting for shortening juvenile phase and improving fruit quality (initiation stage).
4. Pruning to form erect canopy.
5. Protection from animals by dead or live fences.

Maintenance / recurrent activities

1. Weeding around seedlings when necessary (rainy season).
2. Pruning as necessary (pruned branches are dried and used for fuelwood): annually.
3. Pollarding (pruning of side branches to improve light for understorey crops.
4. Felling some trees to reduce density as they grow bigger (during dry season).

All activities carried out by manual labour using machetes (panga) or hoes.

Labour requirements

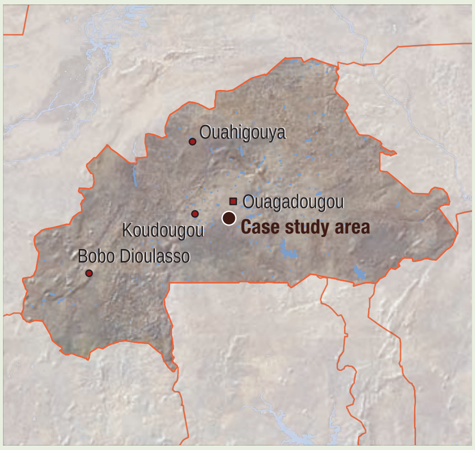
For establishment: moderate
For maintenance: high

Knowledge requirements

For advisors: moderate
For land users: low

Photo 1: *Karité* –millet parkland in Sapone, Burkina Faso. (Jules Bayala)
Photo 2: *Faidherbia albida* dominating a parkland system with pearl millet in Burkina Faso. (William Critchley)

Case study area: Saponé, Burkina Faso



Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	-
Equipment	-
Agricultural inputs	-
TOTAL	**no data**

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	-
Equipment	-
Agricultural inputs	-
TOTAL	**no data**

Remarks: Data on costs is not available. However, costs for management of the land use system are low; only some pruning and trimming of trees is needed which is effectively 'harvesting' of fodder and wood.

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	very positive
Maintenance	slightly positive	very positive

Remarks: Costs of establishment and maintenance in traditional parklands are difficult to quantify because trees usually arise through natural regeneration and then are 'nurtured'. Annual returns from the sale of *neré* products were estimated at 50-60 US$ (26% of farmers' income) and *karité* / shea nut activities can represent 20–60% of women's income in rural areas.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 720 mm (unimodal)
- Soil parameters: sandy loam, Regosols; low soil organic matter
- Slope: mostly flat
- Landform: plains
- Altitude: no data

Socio-economic conditions

- Size of land per household: 1-5 ha
- Type of land user: poor and better-off farmers (basically everyone who has land)
- Population density: 76 persons/km^2
- Land ownership: majority has ownership of the land, few borrow
- Land use rights: individual
- Level of mechanisation: manual labour
- Market orientation: mixed (subsistence and commercial)

Production / economic benefits

+++ Increased production from fruits
++ Increased farm income
\+ Increased fodder production (leaves used as fodder during dry season)
\+ Increased crop yield (through mulching and nutrient pumping)

Ecological benefits

+++ Reduced wind velocity (affecting crops / homesteads)
++ Improved soil cover (mulch and canopy cover)
++ Improved micro-climate
++ Increased soil fertility (leaf litter and nutrient recycling)
++ Reduced soil loss
\+ Increased soil moisture (mulching improves infiltration)
\+ Biodiversity enhancement (bees, birds, etc.)

Socio-cultural benefits

++ Improved conservation / erosion knowledge (stakeholder interaction)
++ Improved housing (more timber available)

Off-site benefits

+++ Reduced deforestation (alternative source of fuel and timber)
++ Creation of employment (tree management and harvesting)
\+ Reduced downstream flooding
\+ Reduced downstream siltation
\+ Increased stream flow in dry season

Weaknesses ➜ and how to overcome

- Seedlings and wildings not always readily available ➜ encourage local seed collection and setting up of group tree nurseries.
- Livestock sometimes damage the young seedlings ➜ protection by fencing.
- Dry periods result in low seedling survival rates: planting not possible in dry areas ➜ combine technology with fencing.
- Competition with crops ➜ regular pruning of side branches.
- Long period to fruiting ➜ use vegetative propagation of superior trees.

Adoption

Tens of millions of people live in the traditional parklands of Burkina Faso, Mali, Senegal and Niger. In Mali alone an estimated 3.6 million people practice parkland agroforestry with 40 trees per hectare.

Main contributors: Jules Bayala, CORAF; secoraf@coraf.org; www.coraf.org
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INTEGRATED CROP-LIVESTOCK MANAGEMENT

Pegged small-stock on harvested cropland, Cape Verde. (Hanspeter Liniger)

In a nutshell

Definition: In Integrated Crop - Livestock Management (ICLM) crops and livestock interact to create synergies, making optimal use of resources. The waste products of one component serve as a resource for the other: manure from livestock is used to enhance crop production (improve soil fertility), whilst crop residues and by-products (grass weeds and processing waste) are supplementary feed for the animals. Grass – and prunings from agroforestry trees - grown on contour conservation barriers, as well as nitrogen-fixing legumes grown under conservation agriculture systems, are further potential sources of fodder. Livestock are integral to most African cropping systems: they provide traction and transport, as well as meat, milk and hides. Improvements to the livestock component of integrated systems include upgraded intensive pastures through shifting night enclosures (kraals / bomas), fodder planting / hay making, and stall feeding ('cut-and-carry'; 'zero grazing') in the more humid areas. Various factors influence the type and effectiveness of crop - livestock interactions, including socio-economic parametres (access to land, labour and capital) and ecological conditions (temperature and rainfall).

Applicability: Integrated crop - livestock systems are common in semi-arid and subhumid (and humid) areas as well as in tropical / temperate highlands. Given the growing demand for livestock products, the subhumid areas are predicted to the best potential to provide most of this increase. ICLM can be applied in many areas, but needs to be adapted and modified to prevailing conditions.

Resilience to climate variability: ICLM systems tend to be relatively well adapted to climatic variability because of their diversity and flexibility – especially when soil and water conservation / water harvesting and agroforestry are integrated into the overall system.

Main benefits: Well managed ICLM (a) increases crop yields; (b) improves soil biological activity and health; (c) builds up fertility through nutrient recycling, the planting of leguminous crops and trees; (d) reduces erosion; (e) intensifies land use, improving profits; and (f) improves livestock productivity and health. Including animals in farm systems increases sustainability and reduces reliance on external inputs. Carbon storage can be high: in one case from West Africa, soil receiving manure for five years had 1.18 t/ha more carbon present than soil treated with plant residues alone (Woodfine, 2009 and FAO, 2007). Nevertheless, the carbon budget of such systems is affected negatively by methane emitted by livestock. ICLM thus reduces poverty and malnutrition, and strengthens environmental sustainability.

Adoption and upscaling: Skillful organisation and management of animals and the land is needed. Rules and regulations have to be followed by all concerned, particularly with regard to exclusion of areas from grazing and in terms of animal health and nutrition. Specific skills can be taught, but much must be learnt through experience.

Development issues addressed	
Preventing / reversing land degradation	++
Maintaining and improving food security	++
Reducing rural poverty	++
Creating rural employment	+
Supporting gender equity / marginalised groups	++
Improving crop production	++
Improving fodder production	++
Improving wood / fibre production	+
Improving non wood forest production	+
Preserving biodiversity	++
Improving soil resources (OM, nutrients)	++
Improving of water resources	+
Improving water productivity	++
Natural disaster prevention / mitigation	+
Climate change mitigation / adaptation	++

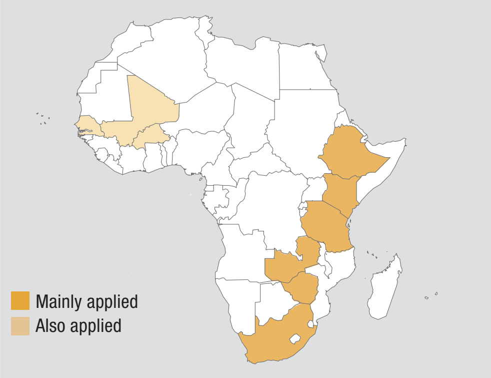
Climate change mitigation	
Potential for C Sequestration (tonnes/ha/year) in silvo / agro-forestry systems	0.1- 0.8* up to 3*
C Sequestration: above ground	++
C Sequestration: below ground	++

Climate change adaptation	
Resilience to extreme dry conditions	++
Resilience to variable rainfall	++
Resilience to extreme rain and wind storms	+
Resilience to rising temperatures and evaporation rates	+
Reducing risk of production failure	++

** for a duration of the first 10-20 years of changed land use management (Source: Woodfine, 2009)*

Origin and spread

Origin: Traditional agriculture in Africa was generally based on mixed crop-livestock systems, with pure livestock production predominating only when rainfall was too low and uncertain to support some form of crop production. Pure arable systems only developed when large-scale mechanised cereal farming was introduced, or where cash crops such as coffee, tea or sugar cane expanded. Animal disease may also have played a role in some areas. Today the re-discovery and modification of traditional techniques, including rotational land use / fallows, mixed cropping, grazing rules and regulations, in combination with agroforestry, improved fodder species, specific soil and water conservation measures (SWC) and more productive livestock breeds, make these systems stronger and more versatile.
Mainly applied in: Ethiopia, Kenya, South Africa, Tanzania, Zambia, Zimbabwe
Also applied in: Burkina Faso, Mali, Senegal



Integrated Crop-Livestock Management in SSA.

Principles and types

ICLM is evolving as a very viable and common farming system, allowing smallholder farmers to capitalise on the complementarity and synergies between crops and livestock for improved cycling of nutrients, efficient resource use, and safeguarding the environment. Some activities / measures in an integrated crop livestock system are:

Animals stall-fed (zero-grazing) has expanded significantly through the introduction in the more humid areas of (particularly) dairy cows. This has led to an all-round intensification of crop – livestock systems. Combined with vegetative SWC measures, based often on napier grass which is an excellent fodder, as well as agroforestry, and sometimes biogas plants, whole farming systems have been upgraded.

Harvesting and relocating nutrients: Crop residues are sometimes stored but most are left in the field after harvest, opportunistically grazed and often underutilised (and spoiled). Land users can paddock animals on cropland or otherwise collect (sometimes store and process) and spread manure on cropland to improve fertility and hence production. In agropastoral systems animals graze freely during the day and are in *kraals* / *bomas* (enclosures for cattle, goats and sheep) or on cropland during the night. The balance of feed that an animal consumes influences the properties of its gaseous emissions (especially methane, CH_4), and manure management is important in this context.

Dual-purpose crops (food-feed) enable farmers to increase unit area productivity with the same resources. Significant advances have already been made in the development and promotion of dual-purpose cowpeas in West Africa and maize in Kenya.

Addition or control of species involves improving grazing land through planting high-value species (e.g. grasses, multi-purpose shrubs / trees) for increased biomass production ('enrichment planting'), eradicating invasive species by selective cutting, while simultaneously encouraging natural regeneration of desirable local species. Under dry conditions, water harvesting techniques can be useful.

Haymaking allows the building up of reserves for the dry season from surplus in the wet. Storing fodder helps animals to survive during dry periods without having to overgraze the land. It is also a buffer in extreme drought when market prices for animals are very low. The conservation of fodder as hay or silage, however, has not been a common practice in small-scale farming systems in SSA due to lack of information on conserving fodder under tropical conditions, and the resilience of local breeds to harsh conditions and poor diets.

Production of forages, grasses and leguminous trees is often through being grown on bunds and intercropped with food or cash crops. Live fences can also serve the same purpose.

Enclosures: If pasture is severely degraded due to overgrazing then fencing (social as well as physical) is often the first step, followed by a period of several years of rest. After good regeneration and regrowth, cut-and-carry or controlled grazing (e.g. rotational grazing) leaving periods of recovery of the vegetation are the management systems that maintain the land's condition.

Animals for field work and transportation constitute an appropriate, affordable and sustainable technology that is used in most countries in SSA. Draft animals, notably cattle and donkeys, provide smallholder farmers with vital power for cultivation and transport. Animal traction can also be used for water-raising, milling, logging, land-leveling and road construction.

Top: Cow stall fed with crop residues, Kenya. (Hanspeter Liniger)
Middle: Transportation of grass for stall feeding, Ethiopia. (Hanspeter Liniger)
Bottom: Stall feeding of dairy cows, Uganda. (William Critchley)

Applicability

Land degradation addressed

Chemical soil deterioration: fertility decline and reduced organic matter content
Biological degradation: reduction of vegetation cover and species composition / diversity decline, loss of fodder value
Poor animal health due to limited availability and quality of feed
Fire is a widely used management practice for vegetation clearance, growth stimulation and pest control. Rangeland and crop residue burning, besides emitting CO_2, reduces soil organic matter and nutrient levels.

Land use

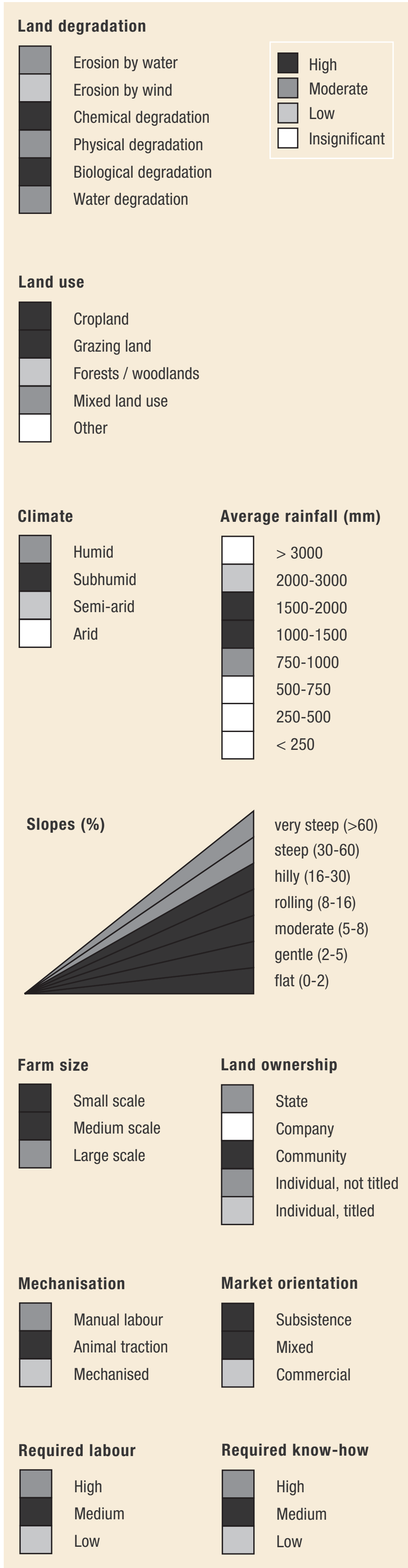
Mainly cropland and mixed land use
Also intensive grazing / fodder production (improved or planted pastures, etc.)

Ecological conditions

Climate: mainly subhumid to humid areas, partly in semi-arid, with rainfall mainly between 750-1,500 mm (though even higher also)
Terrain and landscape: no restrictions whole range from flat to hilly
Soils: no restriction

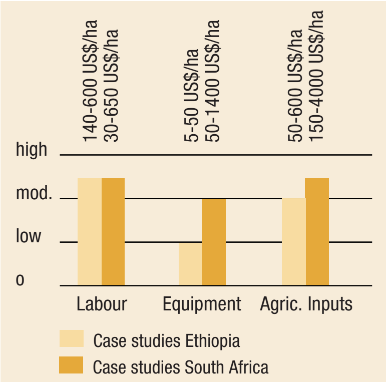
Socio-economic conditions

Farming system and level of mechanisation: Mainly on small-scale to medium-scale farms, mainly animal draught and manual labour, low level of mechanisation (few exceptions: replanting / reseeding).
Market orientation: Mainly subsistence and mixed, but also commercial (e.g. Kenya and South Africa).
Land ownership and land use / water rights: In most cases individual land use rights and communal (organised).
Skill / knowledge requirements: Compared to other SLM practices medium to high, depending on the ICLM management practices applied e.g. if a stall-fed dairy unit is introduced. Land users need to undergo training programmes to learn how to best apply technology, including conserving the land, improving grazing and controlling invasive species. Keeping animals well-fed, healthy and productive needs a high level of skill.
Labour requirements: Medium to high labour requirements for stall-fed livestock with cut-and-carry and high for rehabilitation of grazing land through addition of species with structural and vegetative measures (e.g. for water harvesting). In this case labour requirements are mainly for the establishment phase.

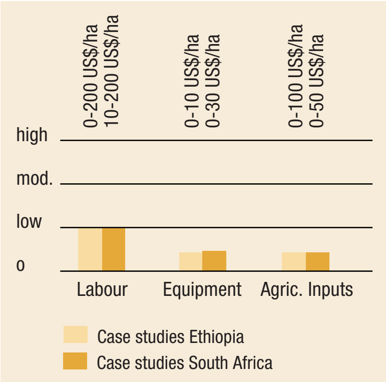


Economics

Established costs



Maintenance costs



(Source: WOCAT, 2009)

Labour costs in US$ are similar between ICLM technologies in Ethiopia and South Africa. In Ethiopia more manual and untrained labour, and in South Africa less but more qualified (therefore more expensive) labour is required.
Establishment costs can be relatively high for fencing materials, and increasing when reseeding / replanting, control of invasive species, water harvesting is added. Maintenance costs are generally low.
In the case of stall-fed livestock, initial costs are high both for purchase of animals and for buildings.
The costs per hectare for ICLM are relatively low compared to other SLM groups, however the generally lower productivity of grazing land compared to cropland, makes a comparison per hectare difficult.

Production benefits

Several studies carried out recently have clearly shown that integration of livestock with crops results in improvements of 50% (Ethiopian highlands) to over 100% (Zimbabwe) or more, in terms of farm productivity and income, compared to smallholders who only raise subsistence crops.
Approximately 25% of the agricultural domestic product in SSA is from livestock, not considering the contributions of animal traction or manure (Winrock International, 1992; in Pell, 1999). When traction and manure are included, livestock contribute 35% of the agricultural domestic product (Pell, 1999).

Benefit-Cost ratio

	short term	long term	quantitative
Fodder / crop / animal productivity	+	++/+++	No data available

– – negative; – slightly negative; –/+ neutral; + slightly positive; ++ positive; +++ very positive

The value of manure and animal traction equals in East Africa the value of meat, and Sub-Saharan Africa as a whole has the potential to increase the total gross value of livestock products by about a third. As mixed crop-livestock systems expand, the relative importance of animal traction and manure will grow (Ogle 1996).

	Percent of gross value of output				
Output	West Africa	Central Africa	East Africa	South Africa	Sub-Saharan Africa
Animal traction	21	3	39	26	31
Manure	4	1	3	2	3
Meat	56	79	38	58	47
Milk	11	12	17	9	15
Eggs	8	5	3	5	4

Example: Senegal
The Rodale Institute Regenerative Agriculture Research Centre in Senegal has worked closely with 2,000 farmers in 59 groups to improve soil quality, integrate stall-fed livestock into crop systems, add legumes and green manures, improve the use of manures and rock phosphate, incorporate water harvesting systems and develop effective composting systems. The result has been a 75-195 percent improvement in millet yields – from 330 to 600-1,000 kg/ha, and in groundnut yields from 340 to 600-900 kg/ha. Yields are also less variable year to year, with consequent improvements in household food security – clearly contributing to CC adaptation (FAO 2007).

Example: Kenya
In the semi-arid highlands of Kenya, water loss by runoff was over 80% of the rainfall due to bare ground. The fodder production was mainly annual grasses and forbs of low value. In a rotational grazing system with a ground cover of more that 40%, runoff was reduced to zero. The cover was mainly from perennial grasses and the production was between 4-8 times higher than on the overgrazed land. Furthermore, it was recorded that under acacia trees high value perennial grasses were preserved even in the overgrazed areas (Liniger and Thomas, 1998).

Impacts

Benefits	Land users / community level	Watershed / landscape level	National / global level
Production	+++ increased crop yield and quality +++ improved livestock nutrition and productivity ++ fodder production / quality increase ++ production diversification ++ providing energy through draft power and (sometimes) biogas	++ reduced risk and loss of production	+++ improved food and security
Economic	++ increased farm income + creation of job opportunities, spreading of labour + recycle resources, reduces need for chemical fertilizer (inputs)	++ stimulation of economic growth + diversification and rural employment creation + less damage to off-site infrastructure	+++ improved livelihood and well-being
Ecological	+++ increased soil fertility and organic matter (improved nutrient recycling) ++ improved soil cover ++ reduce soil erosion (by water / wind) ++ biodiversity enhancement ++ increase animal health + improved water availability + improved micro-climate	+ reduced degradation and sedimentation ++ intact ecosystem + increased water availability + increased water quality + reduced wind transported sediments	++ reduced degradation and desertification incidence and intensity ++ increased resilience to climate change ++ enhanced biodiversity
Socio-cultural	++ improved conservation / erosion knowledge ++ reduced workload (draft power) + improvement in household diets	+ increased awareness for environmental 'health' ++ attractive landscape ++ reduced rural-urban migration	+ protecting national heritage

	Constraints	How to overcome
Production	• Low nutritional value of crop residues • *Tsetse* fly in specific areas • Possibly more vulnerable to disturbances since livestock and crop production are interdependent	➜ supplement with fodder legumes, trees ➜ resistant breeds of livestock (stall-fed)
Economic	• 'Investment' costs can be rather high (e.g. fences, manure transport, seeds and seedlings) • Availability of inputs, e.g. labour and seeds, at times even tractors and implements • On larger scale fencing almost impossible	➜ establish credit and loan systems ➜ community mobilisation, self-help groups, government and project support and using family labour ➜ use thorn bush (encroachment) to make fence or social fencing
Ecological	• Competition for crop residues • Efficient use of biomass • Insufficient livestock and availability of animal manure • Burning of seed / seedlings by manure • Contamination of water by livestock • Increase of incidence by fire	➜ alternative sources e.g. other sources of animal feed ➜ keep animals in stalls; introduce cut-and-carry, initial reduction of stocking rates ➜ amend with green manure, N-fixing trees and / or supplement with chemical fertilizers ➜ modify and adapt mode of application ➜ introduce cut-and-carry, haymaking before grass is too tall and controlled grazing to reduce potential fuel material
Socio-cultural	• Insecurity of land tenure • Access to credit (e.g. veterinary services) • Possible dependence on experts concerning species selection (livestock and crop / feed) and planting methods • Lack of awareness and access to knowledge • More pressure on remaining grazing area (enclosures) • Rotational grazing can fail due to wrong timing • Weak governance and reluctance to observe the existing rules and regulations (lack of control) • Requires 'double' expertise (animal and crops)	➜ set appropriate land use policy ➜ credit schemes and land users associations ➜ create awareness ➜ use enclosures for cut and carry and hay making ➜ intelligent pasture management – knowing when to graze and when to rest ➜ install control and fining mechanism ➜ training and capacity building, strengthening advisory service

Adoption and upscaling

Adoption rate

The adoption rate depends on the specific ICLM system. Land users have basic traditional knowledge needed to integrate livestock and crop production, but because of their limited access to knowledge, assets and inputs – especially dairy cattle - relatively few adopt an upgraded integrated system.

Adoption of enclosures with cut-and-carry depends on availability of land for closure and availability of incentives. Spontaneous acceptance of this practice is relatively low and if it is practised then it is mainly with external support.

It is rare that the initiative is taken by the villages alone. The reasons are numerous inlcuding the decrease of production area, privatisation of land etc.

Upscaling

In semi-arid regions the transition in crop and livestock production from the current relatively extensive, low input/output production to more intensive, higher input/output production presents numerous challenges.

– participation of community right from the beginning, during planning to implementation, to ensure ownership
– availability of land and consensus of the community where the system can be introduced or applied
– secure land use rights and tenure
– need for training and capacity building in use of technology and its benefits
– need for training and support in animal husbandry
– requires change in mindset from 'focus on parts' towards 'the whole system'

Incentives for adoption

For regeneration of pastureland, where intensive structural measures are included, land users often rely on incentives (food-for-work or materials). If seedlings and seed are used, the community might need support to at least initiate their production (e.g. tree and seed nurseries). Where stall-fed dairy systems are put in place, it is common that projects supply an initial cow, and then they are 'repaid' with the first heifer calf.

Enabling environment: key factors for adoption	
Inputs, material incentives, credits	++
Training and education	++
Land tenure, secure land use rights	+++
Access to markets	++
Research	++
Participation (% involvement)	+++
Initial external support	++

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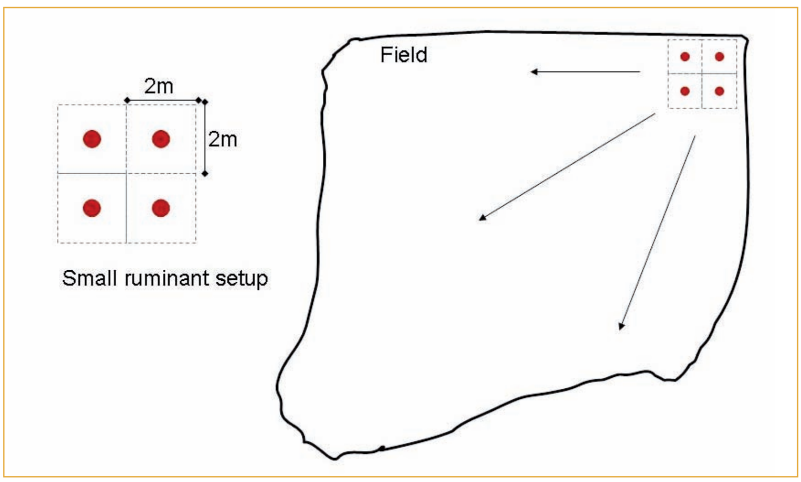
NIGHT CORRALLING - NIGER

Night corralling of cattle, sheep and goats on cropland during the dry season (November-April) replenishes soil fertility of agricultural land depleted by continuous cropping. This technology is mainly applied in semi-arid and subhumid areas on sandy / loamy plains with low soil organic matter content, low soil pH, and with slopes below 5%. Adequate spacing of animals helps to homogenously distribute the manure on the field (see photo): in cattle this is ensured through tying the animals to poles, in sheep and goats a movable fence serving as night enclosure helps to save labour.

Corals and animals are moved to a new spot within the field every 4-5 nights to homogeneously manure fields. Ideal is a rate of 2.5 tonnes of faecal dry matter per hectare. The application of this amount results in superior grain yields (millet, sorghum) as compared to an unmanured field. High yield response is achieved in the cropping season directly following the corralling (year 1) and in the subsequent two to three years, in which no new deposit of faeces and urine, i.e. no further corralling, is needed.

While a 250 kg cow deposits about 1 kg of manure dry matter per night, 7 sheep or 7 goats are needed to produce this same amount. Thus, to cover 1 hectare of land with 2.5 tonnes of manure, a herd of 15 cattle would need to be corralled during 167 nights; alternatively 178 nights would be needed if 70 small ruminants were corralled. Since individual herds are often smaller than 15 cattle (or 70 small ruminants) and fields are larger than 1 hectare, it is recommended to organise corralling of fields within a community (village) of farmers and especially to revitalise the traditional corralling contracts (‘*contrats de parcage*’) with transhumant herders.



SLM measure	Management and agronomic
SLM group	Integrated Crop-Livestock Management
Land use type	Agropastoral and cropland
Degradation addressed	Loss of soil fertility (organic matter, nutrients, pH decline) due to continuous cropping
Stage of intervention	Rehabilitation
Tolerance to climate change	Technology not much affected by climatic extremes or changes

Establishment activities

1. Purchasing the poles.

Maintenance / recurrent activities

In year 1 (of a 3-years cycle):

1. Placing poles in the field at 2m x 2m spacing for small ruminants and at 4m x 4m spacing for cattle, starting at the field border (see technical drawing).
2. Attach individual animals (adult small ruminants, adults or calves if you work with cows) to the pole during night.
3. Shift the poles to an adjacent unmanured part of the field every 4 days in cattle, and every 5 days in small ruminants. To cover the whole field (1 ha) with manure:
   – with 15 cattle you will need a total of 167 nights of corralling;
   – with 70 small ruminants you will need 178 nights.

In year 2 and 3 (of a 3-years cycle):

4. Cultivate the field for 3 subsequent cropping seasons (year of application, plus year 2 and 3) without further corralling in year 2 and year 3.
5. Apply a new corralling treatment in year 4 (repeat maintenance steps 1-4).

Labour requirements

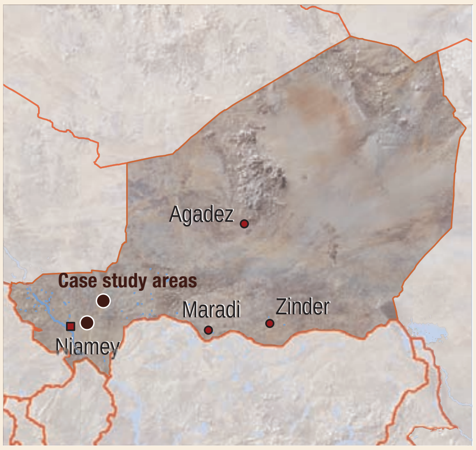
For establishment: low
For maintenance: low

Knowledge requirements

For advisors: moderate
For land users: moderate (spacing and timing of animal placement need to be respected)

Photo 1: Relatively homogenously manured field obtained through night corralling of cattle in south-western Niger. (Pierre Hiernaux)
Technical drawing: Corralling area of 4 sheep to poles (brown circles) during 5 nights (left) and principle of shifting corralling areas across a field of undefined size (right). (Eva Schlecht)

Case study area: Fakara region (near Niamey) and Chikal territory (near Filingué), Niger



Establishment inputs and costs per ha

Inputs (for 1 ha with 15 cattle)	Costs (US$)
Equipment: 15 poles (1 per animal)	15
TOTAL	**15**

Inputs (for 1 ha with 70 sheep)	Costs (US$)
Equipment: 70 poles (1 per animal)	70
TOTAL	**70**

Maintenance inputs and costs per ha per year

Inputs (for 1 ha with 15 cattle)	Costs (US$)
Labour: 1.3 person-days*	3
Equipment: 5 poles (replacement)	5
TOTAL	**8**

** 11 minutes on 167 days in year 1; 0 days in years 2–3*

Inputs (for 1 ha with 70 sheep)	Costs (US$)
Labour: 1.7 person-days*	4
Equipment: 21 poles (replacement)	21
TOTAL	**25**

** 14 minutes on 178 days in year 1; 0 days in years 2–3*

Remarks: Labour costs incur in a 3-years cycle: putting and changing the poles on a specific field is done in year 1, while in years 2 and 3 the respective field is cultivated, and no corralling takes place. Actual labour input for corralling in year 1 is 4–5 days (= 10–15 minutes during approx. 170 days), equivalent to US$ 10–13; maintenance costs given in the tables above refer to the average expenses of the whole 3-years cycle.

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	positive
Maintenance	highly positive	positive

Remarks: Labour input in year 1 (dry season) pays through high yields in harvest seasons of years 1–3.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 250-500 mm
- Soil parameters: well drained, sandy, shallow soils, low to very low soil fertility; low organic matter; low pH (< 4)
- Slope: mostly flat (0-2%), partly gentle (2-5%)
- Landform: mainly plains, partly pediments
- Altitude: 100-500 m a.s.l.

Socio-economic conditions

- Size of land per household: average land holding is 13 ha (near Niamey) and 10 ha (near Filingué)
- Type of land users: small-scale farmers
- Population density: no data
- Land ownership: mostly individual, titled
- Land use rights: individual for fields, communal for pastures
- Market orientation: mostly subsistence (self-supply), partly mixed (subsistence and commercial)
- Level of mechanisation: manual labour

Production / economic benefits

+++ Increased crop yield (in year 1 - 3; corralling only done in year 1)
++ Increased farm income

Ecological benefits

+++ Improved soil organic matter (medium term)
+++ Increased soil fertility
++ Increased water holding capacity
++ Reduced risk of soil crusting

Socio-cultural benefits

++ Revaluation of traditional knowledge
++ Community institution strengthening through rotational corralling of multiple-owner herds on individuals' fields
++ Revitalisation of ties with transhumant groups

Weaknesses

- Implementation constraint: organisation of rotational corralling is necessary to effectively manure fields of a village community; this needs skilful organisation.
- Need to invest in poles.
- High labour investment in year 1.
- Difficulty to revitalise trustful partnership with transhumant pastoral groups, as more and more crop residues are harvested and stored at the homestead (no dry season feed for mobile herds).
- Extensive consultation and coordination is needed if rotational (community) corralling or involvement of transhumant herders is necessary due to low animal numbers (<12 cattle, <50 small ruminants) at the level of individual households.

Adoption

Relatively high, but incomplete in the sense that homogeneity of dung application is lacking.

Main contributors: Eva Schlecht, Animal Husbandry in the Tropics and Subtropics, University of Kassel and Georg-August Universität Göttingen, Witzenhausen, Germany.; schlecht@uni-kassel.de
Key references: Schlecht E., A. Buerkert. 2004. Organic inputs on millet fields in western Niger: the implications of farmers' practices for sustainable agricultural production. Geoderma 121, 271-289 ■ Schlecht E., P. Hiernaux, I. Kadaouré, C. Hülsebusch, F. Mahler. 2006. A spatio-temporal analysis of forage availability, grazing and excretion behaviour of cattle, sheep and goats in Western Niger. Agric, Ecosys Environ 113, 226-242. ■ Schlecht E., H. Richter, S. Fernández-Rivera, K. Becker. 2007. Gastrointestinal passage of Sahelian roughages in cattle, sheep and goats, and implications for livestock-mediated nutrient transfers. Anim Feed Sci Technol 137, 93–114.

ROTATIONAL FERTILIZATION - NIGER

Rotational fertilization is an integrated crop-livestock management measure practised by the agropastoralist *Peulh*. At intervals of 2-3 years they relocate with their livestock to a new area previously used for crop cultivation - where they install their temporary dwellings and improve soil fertility by applying farm-yard manure and other organic materials.

The rotation of temporary habitation areas leads to successive fertilization of the land. Livestock (cattle or small ruminants) are corralled or tethered in the rehabilitation area over-night. They feed on crop residues and emerging grasses after harvesting of the crops. Dung dropped within the coral area is collected and then distributed on the fields. The main criterion for site selection is the level of land degradation. The size of the area occupied is maximum 500 m^2, and depends on family size, herd size and on the quantitative and qualitative objectives of soil fertilization of the land owner.

In the years after settlement (after families move to a new location) the treated area is used for crop cultivation, and crop rotation / intercropping are practiced (e.g. millet / legumes) for increased and diversified production, improved pest control and fertility management.

The effectiveness of this technology has led to field-fertilization contracts between agropastoralists and sedentary farmers. The farmers offer post-harvest grazing rights to the agropastoralists who in turn fertilize the land and benefit from the access to the important weekly markets in the area where they can sell milk. In this case the agropastoralist families and their livestock split up after the rainy season: a part assures fertilization of the own land, the other part is in charge of fertilizing foreign land (during 3-4 months) before returning home.

SLM measure	Management and agronomic
SLM group	Integrated Crop-Livestock Management
Land use type	Cropland: temporarily: settlement area
Degradation addressed	Soil fertility decline; Soil erosion by water; Soil erosion by wind
Stage of intervention	Rehabilitation
Tolerance to climate change	Tolerant to temperature increase and reduction of vegetation period; sensitive to droughts, floods, wind storms and rainfall variability

Establishment activities

1. Identification of site where level of land degradation is high.
2. Level and clean the land.
3. Layout / disposition of infrastructure (dwellings, barns, corral, poles, poultry habitat) according to type and degree of land degradation.
4. Establishment of infrastructure.

Maintenance / recurrent activities

➜ On land being treated
1. On-going fertilization by applying farmyard manure and any kind of organic material accruing from daily human activities to the soil during 2-3 years.
2. Maintenance / re-location of huts to improve fertilization of land (after rainy season).

➜ On previously treated land:
3. Land preparation (ploughing, e.g. cowpea).
4. Cultivation of millet and legumes (‘*niébé*’) as intercrop or in the form of crop rotation.

Labour requirements

For establishment: high
For maintenance: low

Knowledge requirements

For advisory service: na
For land users: low

Photo 1: Dung dropped by animals feeding on crop residues; sheltered corrals in the background. (Pierre Hiernaux)
Photo 2: Millet growing on fertilized fields. (Adamou Kalilou)
Photo 3: Increased yields are an important impact of the technology: millet sold on village market. (Adamou Kalilou)

Case study area: Damari, Kollo district, Tillabéry region, Niger

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour: 100 person-days	150
Construction material: lumber and straw for hut	200
TOTAL	**350**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour: 10 person-days	15
TOTAL	**15**
% of costs borne by land users	100%

Remarks: Establishment of housing infrastructure is done collectively, involving dozens of community members within less than a week. Construction material is taken from the woodlands; many parts are re-used after moving. While expenses are expressed in US$, in reality costs are in kind (mutual help) or not paid for (free lumber). Maintenance activities include: maintenance and re-building of dwellings. Costs for crop cultivation (US$ 335-535 annually) are not included.

Benefit-cost ratio

Inputs	short term	long term
Establishment	positive	very positive
Maintenance	positive	very positive

Remarks: The impact of the measure on soil productivity is increasing in the mid and long term.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 400-550 mm
- Soil parameters: very poor sandy soils with low soil organic matter content, usually well drained (low in case of soil crusting)
- Slope: mostly flat (0-2%)
- Landform: mainly plains / plateaus, valley floors
- Altitude: 0-100 m

Socio-economic conditions

- Size of land per household: 1-2 ha
- Type of land users: groups / community, family; small-scale, poor
- Population density: 10-50 persons/km^2
- Land ownership: mostly individual, untitled
- Land use rights: individual, communal (organised)
- Market orientation: mostly subsistence (self-supply), partly mixed (subsistence and commercial)
- Level of mechanisation: manual labour

Production / economic benefits

+++ Increased crop yield
+++ Increased farm income
+++ Increased animal production
++ Increased fodder quality and fodder production

Ecological benefits

++ Increased soil cover
+++ Reduced wind velocity
+++ Increased soil fertility
++ Increased biomass / above ground carbon
+++ Reduced soil loss
+++ Increased animal diversity

Socio-cultural benefits

++ Conflict mitigation
+++ Community institution strengthening through mutual aid in technology implementation
+++ Improved cultural opportunities

Off-site benefits

+++ Reduced damage on public / private infrastructure
+++ Reduced damage on neighbours' fields
++ Reduced wind transported sediments

Weaknesses ➜ and how to overcome

- Growing costs and decreasing availability of timber and poles for establishment of infrastructure ➜ re-introduce traditional techniques of long term conservation of housing materials.
- High labour input for implementation ➜ reinforce community structures for mutual help.
- Area treated by the technology is too small regarding the area in need of treatment (degraded land) ➜ reinforce the solidarity between communities to increase the treated area.
- Negative effect on the woodland (*brousse tigrée*): cutting for building materials, clearing for cultivation ➜ identify new ecological materials for house construction; tree plantation.
- Marginalisation of families with low activity potential ➜ reinforce mutual help systems to support poor / small families.

Adoption

High spontaneous adoption of this indigenous technology. Its high effectiveness has helped spread the technology to adjacent areas on the other side of the river Niger, where farmers contract the agropastoralists for their 'fertilization service'. The area covered by the technology is approximately 1,500 km^2.

Main contributors: Abdoulaye Sambo Soumaila, Groupe de Recherche d'Etude et d'Action pour le Développement (GREAD), Niamey, Niger; leffnig@yahoo.fr

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GRAZING LAND IMPROVEMENT - ETHIOPIA

Grazing land improvement is based on enclosures and planting of improved grass and fodder trees to enhance fodder and consequently livestock production and simultaneously control land degradation. This case study focuses on the highly populated, humid highlands of Ethiopia where the little remaining grazing land areas are overused and under enormous pressure.

The technology involves a combination of management, agronomic and vegetative measures: fencing to exclude open access, application of compost to improve soil fertility, planting of improved local and exotic fodder species, including multipurpose shrubs / trees (including nitrogen fixing species) legumes, and the local *desho* grass (*Pennisetum pedicellatum*). *Desho* has a high nutritive value and ensures regular cuts. It is planted by splits, which have high survival rates and establish better than grasses which are seeded. Other grass seeds and legumes are mixed with fodder tree seeds and then broadcast. Legumes include alfalfa (*Medicago sativa*) and clovers in some cases. The area is permanently closed for livestock. Fodder is cut and carried for stall-feeding and once a year, grass is cut for hay, which is stored to feed animals during the dry season.

In the study area, the fenced and protected communal grazing land has been divided into small plots (<0.5 ha) and distributed to individual users for cutting hay, as an incentive to stimulate proper management. The government provides training, technical assistance, close follow-up, and some inputs for initial establishment.

SLM measure	Management, agronomic and vegetative
SLM group	Integrated Crop-Livestock Management
Land use type	Extensive grazing (before), silvopastoral (after)
Degradation addressed	Soil erosion by water; Fertility decline
Stage of intervention	Rehabilitation
Tolerance to climate change	Tolerant to rains with high intensity, storms

Establishment activities

1. Delineate the area to be conserved and establish a fence (deadwood).
2. Subdivision of protected (communal) land into individual plots of 0.3 – 0.5 ha.
3. Prepare seedlings in nurseries (grass splits and tree seedlings).
4. Prepare seedbed (with a hand hoe, partly with oxen plough).
5. Prepare compost / manure (ash, animal manure, leaf litter, soil, water).
6. Plant grass splits and tree / shrub species in lines and on conservation bunds; sow grass seed by broadcasting (early rainy season).
7. Compost application (one month after planting).
8. Weeding.

Maintenance / recurrent activities

1. Cut and carry grass and leaves to feed stall-fed animals (after 2-3 months growth, during rainy season, end of August).
2. A final cut for hay making is taken early in the dry season (end of October) when the grass has matured well.
3. Weeding.
4. Enrichment planting and gap filling (once a year), combined with application of compost / manure (mixed with soil).

Labour requirements

For establishment: high
For maintenance: low

Knowledge requirements

For advisory service: high
For land users: moderate

Photo 1: *Desho* grass and multipurpose trees established to increase productivity of grazing lands.
Photo 2–3: Cut and carry of grass for stall-feeding from improved pasture. (All photos by Daniel Danano)

Case study area: Chencha, Ethiopia

Establishment inputs and costs per ha

Inputs (for 1 ha with 15 cattle)	Costs (US$)
Labour	320
Equipment	22
Agricultural inputs	710
TOTAL	**1,052**
% of costs borne by land users	56%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	35
Equipment	4
Agricultural inputs	87
TOTAL	**126**
% of costs borne by land users	100%

Remarks: Seedlings are given by the government for initial establishment. For further extension of area and replanting, the land users set up their own nurseries. After 2–3 years maintenance costs decrease substantially as the grass cover closes up and maintenance activities such as replanting and compost application are reduced or cease. The local daily wage is about US$ 0.70 a day.

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	very positive
Maintenance	positive	very positive

Remarks: Milk production compensates for some of the high investment costs (previously, production was low).

Ecological conditions

- Climate: humid (local term: *wett dega*)
- Average annual rainfall: 1,000-1,500 mm
- Soil parameters: good drainage; mostly medium soil organic matter, partly low
- Slope: moderate (5-8%) to rolling (8-16%), partly hilly (16-30%)
- Landform: ridges and hillslopes, partly footslopes
- Altitude: mostly 2,000-2,500 m

Socio-economic conditions

- Size of land per household: < 1 ha
- Type of land user: small-scale farmers (individually), mainly poor land users, partly average level of wealth
- Population density: 200-500 persons/km^2
- Land ownership: state
- Land use rights: individual for cropland, usually open access (communally used) for grazing land, except for the case study area where the rights to rehabilitated grazing land are given to individuals
- Market orientation: subsistence (self-supply)
- Level of mechanisation: manual labour

Production / economic benefits

+++ Increased livestock production
+++ Increased fodder production and fodder quality
++ Increased income (selling animals and their products)
+ Increased wood production

Ecological benefits

++ Improved soil cover
+++ Increased soil fertility
+++ Reduced soil loss
+++ Increased soil moisture
+ Biodiversity enhancement

Socio-cultural benefits

+++ Improved household diets (milk), improved health
+++ Community institution strengthening
+++ Increased willingness of the national institution to assist and support organised farmer groups (i.e. community institutions)
+++ Improved conservation / erosion knowledge
++ Increased availability of livestock products on the market (lowers prices for the consumers)

Off-site benefits

+++ Reduced transported sediments
++ Reduced downstream flooding
++ Reduced downstream siltation
++ Increased stream flow in dry season

Weaknesses ➜ and how to overcome

- At the initial stage of establishment it is very labour intensive ➜ use of improved land preparation methods such as oxen ploughing.
- It is an expensive technology (availability of cash for inputs, particularly seedlings) ➜ produce seedlings of improved species and compost in backyards.
- Needs high fertiliser application ➜ focus mainly on organic fertilizers.
- High pressure on remaining grazing areas ➜ keep animals in stall (stable) or park, at least part of the day and during the night and introduce cut-and-carry more widely.

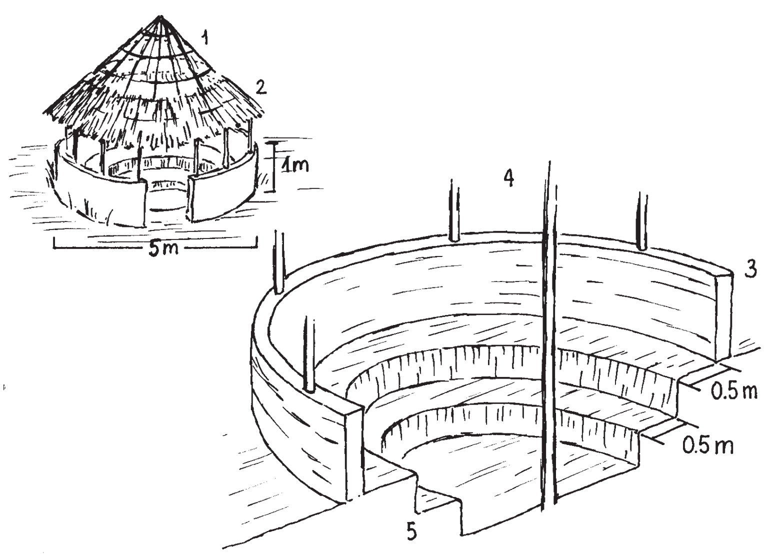
Adoption

The 50 households who accepted the technology in the initial phase, did so with incentives. They were provided with planting material and hand tools. The rate of spontaneous adoption is very high. At present over 500 households have taken up the technology and the total area covered is about 20 km^2.

Main contributors: Daniel Danano, Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia; ethiocat@ethionet.et
Key references: Adane Dinku, Chencha Wereda, Natural Resources Management Annual Report, 2001 and 2002 ■ Danano, D (2008, unpublished): Soil and Water Conservation Practices for Sustainable Land Management. WOCAT. 2007. ■ WOCAT database on SLM technologies. www.wocat.net

SMALLSTOCK MANURE PRODUCTION - TOGO

Smallstock manure production is an easy and efficient method to produce organic fertilizer for the conservation and improvement of soil fertility. The main item within this practice is the so-called *fosse fumière* - a 1-2 m deep and 3-4 m diameter circular pit, enclosed by a stone wall. The pit has a double function: it is the place where manure is produced and it serves as shed for small ruminants (goats, sheep), particularly to avoid uncontrolled grazing / browsing during the cropping season (from April until November). Animals are fed in the fosse, and they drop their faeces, which together with chopped organic material accruing from the kitchen and field activities, piles up in the pit for decomposition.
The fosse is partly roofed to provide optimal micro-climatic conditions: partial shading, partial exposure to sunlight and appropriate moistening through rainfall. Inside the pit, one or more circular terraces (0.5 m high, 0.5 m wide) serve as resting area for the animals. The terrace riser need to be plastered or reinforced with stones, particularly in case of loose soil, to avoid damage caused by animal trampling.
After decomposition the manure is removed from the pit and distributed on the fields beginning of each cropping season (March). Then straw bedding is renewed and the process starts from scratch. During the dry season from December to March smallstock is left to graze freely on the fields and pastures.



SLM measure	Management and agronomic
SLM group	Integrated Crop-Livestock Management
Land use type	Mixed: Agropastoralism
Degradation addressed	Fertility decline, reduced organic matter content
Stage of intervention	Mitigation and rehabilitation
Tolerance to climate change	Technology not much affected by climatic extremes or changes

Establishment activities

1. Delimitation of the perimeter of the pit and the position of the steps.
2. Excavation of the pit, shaping a terraced structure: 1-3 circular, 0.5 m high and 0.5m wide terraces.
3. Build up a stone wall around the pit, spaced at minimum 0.5 m from the pit, with an integrated gate.
4. Build a roof, which partly covers the pit.
5. Put straw on the ground and corral the animals.
6. After one year (April to March) the compost is ready for application on the field.

All activities carried out by manual labour.

Maintenance / recurrent activities

1. Continuous depositing and piling up of vegetative material (dung, kitchen waste, crop residues).
2. Let decompose the organic material inside the pit (during 1 year).
3. Twice a year (between April and November) the material is actively mixed for aeration.
4. Distribute the manure on the fields (during rainy season).

Labour requirements

For establishment: high
For maintenance: moderate

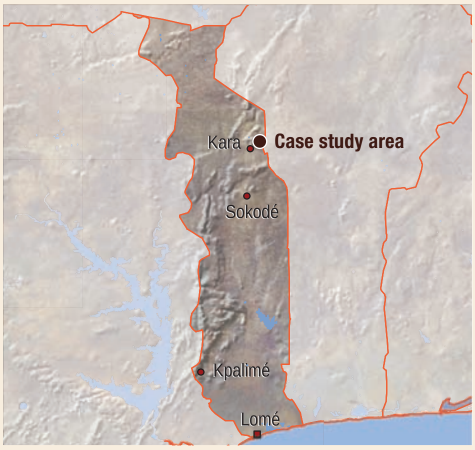
Knowledge requirements

For advisory service: moderate
For land users: moderate

The technology was early traditional and passed from father to son. It was improved in 1987.

Photo 1: Manure production with small ruminants. (Idrissou Bouraima)
Technical drawing: Dimensions and main components of a manure production pit: (1) open part of the roof; (2) covered part of the roof; (3) stone wall; (4) poles (holding the roof); (5) terraces (where animals can rest).(Mats Gurtner)

Case study area: Lassa, Kara, Togo



Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour (36 person-days)	200
Equipment*	182
Agricultural inputs	0
TOTAL	**382**
% of costs borne by land users	100%

**poles, crossbars, stones / bricks, rope, etc*

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	150
Equipment	0
Agricultural inputs	0
TOTAL	**150**
% of costs borne by land users	100%

Remarks: Main cost-relevant factor is labour. Material such as stones and straw are available on the farm (no monetary costs).

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	positive
Maintenance	slightly positive	positive

Ecological conditions

- Climate: subhumid
- Average annual rainfall: 1,000-1,500 mm
- Soil parameters: good drainage; low soil organic matter
- Slope: mostly flat (0-2%), some gentle (2-5%)
- Landform: mostly plateaus / plains, some footslopes
- Altitude: < 100 m a.s.l.

Socio-economic conditions

- Size of land per household: 1-2 ha
- Type of land users: small-scale farmers; average level of wealth, partly rich land users; technology implementation mostly done individually, sometimes in groups
- Population density: 300 persons/km^2 in the region
- Land ownership: individual, titled
- Land use rights: mostly leased, some individual
- Level of mechanisation: manual labour
- Market orientation: mainly mixed (subsistence and commercial), partly subsistence

Production / economic benefits

\+ Increased crop yields
\+ Increased farm income

Ecological benefits

++ Increased soil fertility / soil organic matter
\+ Increased soil moisture

Socio-cultural benefits

++ Increased conservation / erosion knowledge
\+ Improved food security

Weaknesses ➜ and how to overcome

- Manual construction is very labour-intensive ➜ mechanised excavation.
- Air pollution through smelly animal dung ➜ add products which attenuate the smell; establish the manure pit outside the residential area.
- Accident risk for children ➜ establish the manure pit outside the residential area.

Adoption

The technology covers an area of 0.15 km^2. All land users in the study area (totally 60) have adopted the technology voluntarily, without any external support other than technical assistance. There is a moderate trend towards further spontaneous adoption (about 60 %), depending mainly on the availability of livestock.

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Key references: WOCAT. 2007. WOCAT database on SLM technologies. www.wocat.net

PASTORALISM AND RANGELAND MANAGEMENT

Silvopastoral system, Senegal. (Christoph Studer)

In a nutshell

Definition: Pastoralism and rangeland management refer to extensive production of livestock using pastures and browse, and is mainly found in arid and semi-arid areas. In SSA the term 'pastoralism' is usually associated with the use of common property resources subject to some group agreements rather than 'open access'. 'Ranching' on the other hand implies individual, privatised land ownership. Pastoralism is based on open grazing lands, e.g. savannas, grasslands, prairies, steppes, and shrublands, managed through herding. Pastoralists adopt opportunistic land use strategies, that is they follow resources of grazing / browsing and water, destock in times of drought (often *de facto* through livestock mortality rather than stock sales) but have rapid response post-drought restocking strategies (commonly based first on the high reproduction rates amongst indigenous sheep and goats).
There are many types and degrees of pastoral mobility, which vary according to environmental conditions or the given household situation. Mobility can be seasonal, regular between two well-defined pasture areas, or following erratic rain. It is rarely the same from one year to another. Movement is not necessarily undertaken only for resource-based reasons; it can be for trade or because of conflict.
Pastoral activities have conventionally been considered uneconomic and ecologically destructive. Current thinking increasingly recognises these strategies as economically viable, environmentally sustainable, and compatible with development. The challenge is to adapt traditional pastoralism to today's changing environmental conditions. Establishment of feed banks, improvement of herd composition and health, a more dense distribution of wells, collection and storage of surface water by, for example, 'charco dams', adaptive grazing, land use plans, access to markets, and empowerment are such opportunities.
Applicability: A production system for marginal, dry lands: relatively low inherent productivity due to aridity, altitude, temperature and / or a combination of all factors. Pastoralism is becoming increasingly constrained because of weakening of traditional governance over communal natural resources, restricted mobility, sedentarisation, boundaries and advancing agriculture.
Resilience to climate variability: By definition pastoralism is based on continuous adaptation to highly uncertain environments, especially climate. Traditional pastoralism has / is losing flexibility and options for coping with drought (e.g. loss in mobility due to encroachment of cropping and growing human populations) leading to increased risk.
Main benefits: Mobile herding systems combine economic production in marginalised land and environmental protection (biodiversity) of vulnerable ecosystems, which have been modified over time by pastoralism itself; improved food security and livelihood of marginalised and disadvantaged people. The vast areas of degraded rangeland play a vital role in sequestering carbon. Dry soils are better longer term sinks for C than soils in more humid environments.
Adoption and upscaling: Effective pastoral management of the drylands depends on livestock mobility (access to dry season grazing sites and water points), effective communal tenure and governance systems, and herd adaptation.

Development issues addressed	
Preventing / reversing land degradation	++
Maintaining and improving food security	++
Reducing rural poverty	++
Creating rural employment	+
Supporting gender equity / marginalised groups	+++
Improving crop production	+
Improving fodder production	+++
Improving wood / fibre production	++
Improving non wood forest production	++
Preserving biodiversity	+++
Improving soil resources (OM, nutrients)	++
Improving of water resources	++
Improving water productivity	++
Natural disaster prevention / mitigation	++
Climate change mitigation / adaptation	++

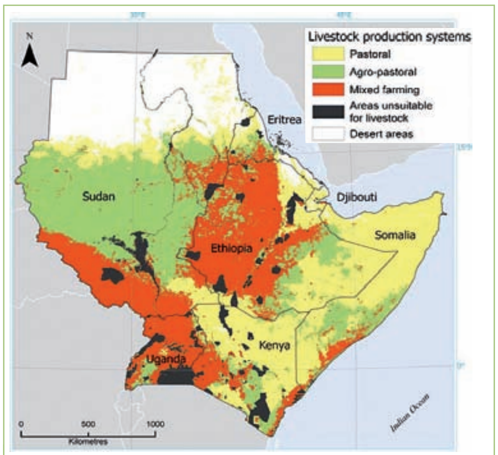
Climate change mitigation	
Potential for C Sequestration (tonnes/ha/year)	0.1 - 0.3*
C Sequestration: above ground	+
C Sequestration: below ground	++

Climate change adaptation	
Resilience to extreme dry conditions	+++
Resilience to variable rainfall	++
Resilience to extreme rain and wind storms	++
Resilience to rising temperatures and evaporation rates	+++
Reducing risk of production failure	++

**for proper rangeland management in US$ and for a duration of the first 10-20 years of changed land use management (Schumann et al., 2002 in FAO, 2004).*

Origin and spread

Origin: Pastoralism is one of the most ancient forms of agricultural activity and pastoralists maintain diverse cultures, ecological adaptations, and flexibility in management systems. It evolved in arid and semi-arid regions as a result of increasing population densities and domestication of livestock. Pastoralism made efficient use of the extensive rangelands, and could cope with climate variability - particularly uneven and erratic distribution of rainfall. Between 1960s and 1980s international donors invested heavily in rangeland and livestock projects by introducing 'ranching' models where boundaries were delineated and destocking programmes encouraged or enforced. These misguided efforts to develop livestock systems have contributed to the current vulnerability of many pastoralists.
Mainly applied in: the arid and semi-arid zones extending from Mauritania to the northern parts of Chad, Eritrea, Ethiopia, Kenya, Mali, Niger, Somalia, Sudan, Tanzania and Uganda. Pastoralists who are principally dependent on camels are confined to areas north of the equator. Communities practicing agropastoralism are found throughout: opportunistic cropping (sometimes based on RWH) is common in 'pastoral' areas.
Also applied in: arid zones of Namibia, parts of Botswana and southern Angola.



Modelled distribution of livestock production systems in Eastern Africa (Source: Cecchi et al, 2010).

Principles and types

Traditional pastoral systems utilise, modify and conserve ecosystems by extensive grazing / ranching with rotational grazing and by using a variety of livestock: sheep and cattle, principally as grazers; and goats, donkeys and camels as browsers.
The Fulbe / Fulani herders in Nigeria, for example, faced with rapidly vanishing grass, switched from the Bunaji cattle breed, which depends on grass, to the Sokoto Gudali, which readily browses (FAO, 2001).
Nomadism: Nomads are livestock producers who grow no crops and depend on the sale or exchange of animals and their products to obtain food (e.g. Tuareg and Fulbe). Their movements are opportunistic and follow pasture and water resources in a pattern that varies from year to year according to the availability of resources.
Transhumance is the regular movement of herds between fixed points in order to exploit the seasonal availability of pastures. A feature of transhumance is herd splitting; the herders take most of the animals to search for grazing, but leave the resident community with a core of lactating female cows and / or camels (e.g. Maasai and Fulbe). For the Fulbe it follows a century–old grazing route northward to the borders of the Sahara, and southward to the moist savanna during the wet and the dry seasons, respectively. Available grazing lands are diminishing and movement channels are blocked through land use change, urbanisation, and frontiers. In West Africa, governments have tried to demarcate transhumance corridors and to legislate for trans-boundary mobility.
Agropastoralism describes settled pastoralists, who live in villages and cultivate sufficient areas to feed their families and keep livestock as valued property (herds are usually smaller). Mixing of crops and livestock primarily serves to minimise risk: failed crops provide animal fodder for example.
Mixed systems: Traditionally some systems are mixed where crops and livestock are managed by different communities based on a long standing relationship. After harvest of the crop, pastoralists are allowed to feed their livestock on the residues. However, since keeping livestock has been promoted amongst crop farmers, this practice is diminishing in importance.
Enclosed systems and ranching: Land is individually owned and usually fenced. In the colonial era, livestock ranches were established in Botswana, Kenya, Namibia, Mozambique, South Africa and Zimbabwe and a substantial proportion of these remain today. Animal movement and pressure are adjusted to the available fodder within the ranch by controlled and rotational grazing and well distributed water points thus reducing degradation as much as possible.

Top: Cattle and camels in a pastoral system, Kenya. (Wiliam Critchley)
Middle: Livestock in a pastoral system, Mali. (William Critchley)
Bottom: Livestock ranching close to a water point on a private estate, South Africa. (William Critchley)

Applicability

Land degradation addressed

In the pre-colonial era, pastoralists were limited principally by disease and insecurity. In the twentieth century occupation of land by cultivators (competition for water and land) and the presence of boundaries impeded free movement of livestock which led to overgrazing of vegetation and soil resources. Overgrazing is a function of time (grazing and recovery) and not simply numbers of animals. Most of the environmentally harmful effects of livestock production in dry areas occur around local water points and settlements.

Biological deterioration: Grazing reduces soil cover and changes the composition of the vegetation. Both, heavy and light grazing can reduce the density of palatable perennial species, which are replaced by less palatable ones as their competitive ability declines.

Water degradation: Low and unreliable rainfall, pasture degradation leading to reduced water infiltration and limited permanent sources of surface water can exacerbate competition for water.

Land use

Mainly extensive grazing land: natural, semi-natural grasslands, savannas, shrubland (*brousse*).

Ecological conditions

Marginal lands and challenging climates with heterogeneity and high variability of resources in space and time. Low in *tsetse* infestation.

Climate: pastoralism: in semi-arid zones with <600mm annual rainfall and a growing season of less than 120 days; seasonal mobility: every wet and dry season; agro-(silvo-) pastoralist systems: semi-arid zones with rainfall ranging between 650 - 1,000 mm. Length of growing period: 130–170 days.

Terrain and landscape: no restrictions - whole range from flat to hilly.

Soils: no restrictions; camels, cattle, donkeys, sheep and goats can utilise a broad range of poor quality forage thriving on marginal soils.

Socio-economic conditions

Pastoralists are usually the most politically and economically marginalised, have the least access to resources (land, water, pasture) and basic services such as health and education and suffer from insecurity, conflicts, poverty, environmental degradation and exposure to climatic risks.

Market orientation: Pastoralists sell livestock products (meat and milk) and livestock to local and domestic markets through both formal and informal channels. Cross-border trade is common. In contrast to crops - where crop failure due to drought results in price increase - livestock destocking, in response to drought, results in price decrease due to a market flooded with poor quality animals. Caravan trade, for example using camels to carry salt, still exists in inaccessible regions of the pastoral zone, but its economic importance has been much reduced by modern transport.

Land ownership and land use / water rights: Pastoralists, due to their opportunistic grazing strategies, have fluid tenure systems that are traditionally based in customary arrangements. However, in some places these have broken down, and uncontrolled open-access regimes have emerged. Traditional wells are often collective property of a community who dug and / or maintained them, but access rights for other groups are usually negotiable. Surface water sources have less clear ownership. A combination of land 'privatisation', fragmentation of communally grazed land, loss of key resources (e.g. water points on transhumance routes), creation of barriers (fences, national parks, roads), imposition of state and district boundaries hamper these rights.

Skill / knowledge requirements: High but exist traditionally and are passed on through the generations.

Labour requirements: A weak relationship between herd size and labour up to the point at which herds beyond a certain size cannot be managed with household labour alone, and outside herders must be hired. In pastoral societies women are typically responsible for milking and dairy processing and for feeding the family. Men are responsible for herding and selling livestock products. In systems with split herds, women stay at the homesteads while men move with the animals.

Land degradation

- Erosion by water
- Erosion by wind
- Chemical degradation
- Physical degradation
- Biological degradation
- Water degradation

- High
- Moderate
- Low
- Insignificant

Land use

- Cropland
- Grazing land
- Forests / woodlands
- Mixed land use
- Other

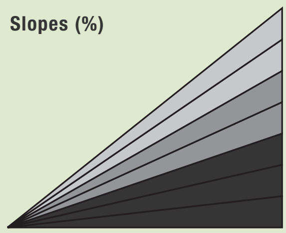
Climate

- Humid
- Subhumid
- Semi-arid
- Arid

Average rainfall (mm)

- > 3000
- 2000-3000
- 1500-2000
- 1000-1500
- 750-1000
- 500-750
- 250-500
- < 250

Slopes (%)



- very steep (>60)
- steep (30-60)
- hilly (16-30)
- rolling (8-16)
- moderate (5-8)
- gentle (2-5)
- flat (0-2)

Farm size

- Small scale
- Medium scale
- Large scale

Land ownership

- State
- Company
- Community
- Individual, not titled
- Individual, titled

Mechanisation

- Manual labour
- Animal traction
- Mechanised

Market orientation

- Subsistence
- Mixed
- Commercial

Required labour

- High
- Medium
- Low

Required know-how

- High
- Medium
- Low

Economics

Establishment and maintenance costs

Pastoralism entails high marketing and transaction costs, especially because of the absence of formal markets and existing monopolies, high transport costs, poor infrastructure, long distances to processing plants, poor access to information, lack of financial services such as credit facilities, and excessive government bureaucracy and fees. Transaction costs reduce the returns to labour under pastoralism.

Production benefits

Pastoral production provides multiple products. It tends to focus on animal products (especially milk), rather than animals for slaughter.

Annual direct values accruing per TLU* of cattle in Afar (Ethiopia)	
Direct value	US$
Estimated annual value of milk	54
Mean annual livestock sales	15
Annual herd growth rate	9
Total	78

** Tropical Livestock Unit, 4 hectares of rangeland per TLU (Source: Hatfield and Davies, 2006)*

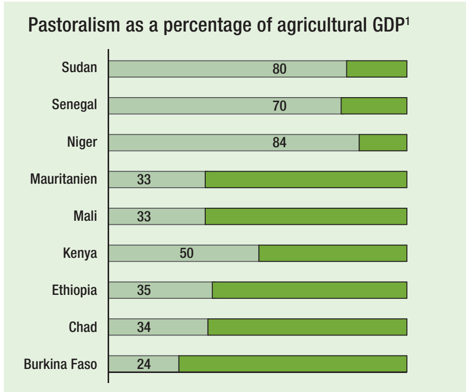
This data does not capture the full direct value of pastoralism in Afar as it omits the value of leather, the value of processed butter and the transportation values of camels and donkeys. Nevertheless, the data provides an estimated mean pastoral livestock productivity of US$ 78 per 4 hectares. This range of products and species can make pastoral systems significantly more cost-effective and productive than the meat-focussed ranching models that have been promoted.
Transhumance in particular is an extremely productive system, yielding between 50 and 600% more protein per ha than ‘modern’ ranching in comparable ecological areas within the USA and Australia (Ogle, 1996). In Sub-Saharan Africa the economic importance of livestock rises as rainfall declines.

Benefit-Cost ratio

Pastoralism has considerable economic value and latent potential in the drylands but little is known or has been quantified. It encompasses less tangible benefits including financial services (investment, insurance, credit and risk management), ecosystem services (such as biodiversity, nutrient cycling and energy flow) and a range of social and cultural values.
The value of livestock production in the drylands is often grossly underestimated in official statistics, and thus does not attract the investment attention that it deserves.

Example: African pastoralism has been shown to out-produce ranching
In Botswana, communal area production (in cash, energy and protein terms) per hectare exceeds - by at least three times per hectare - returns from ranches in Australia and North America. The difference in soil erosion levels between the two production systems is negligible, despite much higher stocking rates under the communal areas (in Hatfield and Davies, 2006).

Example: Transhumant pastoral systems
In Mali, transhumant pastoral systems yield on average at least two times the amount of protein per hectare per year compared to both sedentary agropastoralists and ranchers in the US and Australia (in Hatfield and Davies, 2006). Pastoralism is economically viable to the extent that it contributes significantly to the economy of many developing countries despite continued underinvestment (Hatfield and Davies, 2006).



1 Gross Domestic Product

Impacts

Benefits	Land users / community level	Watershed / landscape level	National / global level
Production	+++ increased animal productivity ++ greater production and better survival of arid rangeland plants (fodder) ++ greater diversity of livestock and goods that are produced + improved crop yields	+++ maximising production in a highly variable environment ++ reduced risk of production	++ improved food security
Economic	+++ high overall returns due to multiple benefits ++ provides a stable livelihood (e.g. Maasai, Fulbe pastoralists)	++ can contribute 'significantly' to the national economy ++ diversification and rural employment creation ++ less damage to off-site infrastructure + enables drylands to be economically exploited	+ improved livelihood and well-being
Ecological	++ increasing live plant cover ++ reduced soil erosion (by water / wind) ++ efficient and flexible way of managing sparse vegetation and relatively low soil fertility ++ biodiversity enhancement ++ reducing old vegetation (threat of fires) + improved water availability + improved micro-climate	++ reduced degradation and sedimentation ++ efficiency of opportunism in environments that are characterised by uncertainty (intact ecosystem) + increased water availability + increased water quality	++ maintained ecosystem integrity and resilience to climate variability ++ reduced degradation and desertification incidence and intensity ++ enhanced biodiversity
Socio-cultural	++ pastoralists traditional knowledge of environment, livestock genetics, livestock breed selection, medicinal plants and weather forecasting	+ increased awareness for environmental health ++ attractive landscape ++ reduced conflicts	+++ protection of national heritage ++ knowledge leading to sustainability

	Constraints	How to overcome
Production	• Availability of feed / fodder in quantity and quality during the dry season • Increase productivity without adverse environmental consequences	➜ allow sufficient flexibility to move and destock; In SSA products such as cotton seed, groundnut cakes and molasses are now regularly sold to pastoralists, together with mineral licks
Economic	• Poor livestock prices due to lack of marketing infrastructure and knowledge of prices • Access to markets and financial services (credits and savings) • Milk (mainstay of most pastoral economies) not well marketed leading to a shift in production towards meat • Many young people now go to school, while others are moving to the cities to do unskilled jobs (availability of labour)	➜ processing facilities for dairy products and better marketing strategies ➜ Encourage banking facilities: spread of mobile phones and mobile phone-based banking; create alternative saving and investment opportunities ➜ improve image of pastoralism and show its potentials
Ecological	• Sufficient and efficient recovery of nutrients that were relocated from grazing land to cropland • Bush encroachment • Risk and vulnerability of the system	➜ reinforce customary ability to manage rangelands ➜ human capital development (education and health)
Socio-cultural	• Limited livestock mobility • Competition and conflicts over rangelands of pastoralists, farmers and foragers • Wealthier farmers and urban farmers invest their surplus capital in livestock (competition) • Sedentarisation • Traditional tenure systems (usually gained through cultivation), land access and fragmentation • Marginalisation of pastoralists (often seen as backward, archaic and a political threat) • Low education of pastoralists • Inappropriate training of extension agents and absence of useful extension packages • Inappropriate policies aiming at transforming rather than enhancing pastoralism	➜ e.g. demarcation of transhumance corridors and legalisation for trans-boundary mobility ➜ make use of group or collective rights (policies often exist) re-aggregation of fragmented grazing land to still use land communally and / or leasing arrangements ➜ qualify what pastoralists contribute to the economy ➜ political empowerment ➜ capacity building ➜ technical and institutional reforms ➜ put in place or emphasise land reforms and land use rights that support pastoralism

Adoption and upscaling

Adoption rate

Despite the high investments that were made in rangeland development projects during the last 30 years, they have generally been a failure because they based their assumptions on concepts of equilibrium systems developed for individually owned ranching systems. The projects, by changing traditional patterns of land use, weakened the indigenous pastoral production systems by misidentifying 'pastoral crisis'. Collective action arrangements are emerging:

– Awareness of pastoralists themselves
– Economic diversification
– Intensification and diversification of livestock production strategies
– Empowerment of communities through Community-Based Natural Resource Management (CBNRM)
– Reinforcement of favourable land and water use rights, access to resources and regional planning

Upscaling

Planning for / with pastoral societies must have a long term perspective, and needs to recognise that herds will recover eventually, as they always have in the past, and that the utilisation of 'inaccessible' zones will always be the preserve of pastoralists. New policy must address issues of diversity without undermining the common factors that unite pastoralists everywhere in Africa. A key is to enable pastoralists themselves to adapt and enhance their production system (e.g. through improved animal health). Adequate attention needs to be placed on learning from pastoralists' production methods and finding ways to fit new technologies into those systems.

One problem that is rarely addressed is the lack of security (e.g. theft) which acts as an inhibitor to outside investment and which leads people to invest a lot of their resources in providing their own security. Furthermore, in many places where smuggling and trade are key sources of income, pastoralists' economic dependence on livestock is low. Therefore herders may not make investments required in their livestock because their attention is directed elsewhere.

Incentives for adoption

Incentives for key elements of pastoralism such as communal tenure, seasonal movements, flexible stocking rates that can be adopted afresh are:

– legal support for communal arrangements
– legislation for transhumance
– relevant services that are tailored to the needs of communal and mobile management
– infrastructure / investments and technologies for access to water
– insurance and credit services
– animal health programmes
– market integration to survive on smaller herds than would be possible with exclusive subsistence
– promotion of mobile phones for information sharing (animal prices; climate prediction) and for banking
– contingency planning for disaster mitigation / emergency relief

Enabling environment: key factors for adoption	
Inputs, material incentives, credits	+
Training and education	+
Land tenure, secure land use rights	+++
Improved marketing	++
Research	++
Enabling policies	+++
Maintain mobility (trans-boundary)	+++
Safety net (risk and emergencies)	++
Access to services	++

Example: Ethiopia
Communal grazing lands are important sources of livestock feed in developing countries. In the highlands of Tigray, northern Ethiopia rural communities have a long tradition of developing and enforcing use and regulations of grazing areas. Restricted use of grazing lands tends to be maintained once it is established. Village organisations are responsible for the management with technical assistance from the regional Bureau of Agriculture (Gebremedhina et al, 2004).

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NGITILI DRY-SEASON FODDER RESERVES - TANZANIA

Ngitili are traditional enclosures for in-situ conservation and rehabilitation of vegetation, practiced by the Wasukuma agropastoralists in Shinyanga, Tanzania. Shinyanga is a semi-arid area characterised by shortage of fodder associated with problems of deforestation, fuelwood scarcity, food insecurity, declining soil fertility, severe soil erosion and unsecure land use rights. *Ngitili* is a dry-season fodder reserve, an indigenous practice which has been revived by a government programme from 1986-2001.

For initial regeneration of the vegetation and rehabilitation of denuded land absolute exclusion of up to 5 years is needed. Then, areas of standing vegetation are enclosed seasonally from the onset of the rainy season till the peak / end of dry season, before they are opened up for grazing. Two distinct vegetation strata are identifiable, an upper stratum dominated by trees and shrubs (*Acacia tortilis, A. nilotica, A. polyacantha* and *A. seyal)* and a lower stratum of grasses, herbs and forbs. Structure and composition of the *ngitili* areas are closely influenced by location, age, management practices and intensity of use. The reserves are established on degraded land and around homesteads. Individual plots usually reach 2-5 ha in size, while communal *ngitili* cover 10-200 ha. Mostly, the boundaries are not rigidly marked, and physical barriers are not established. Local guards and community by-laws are used to protect and enforce the system.

Ngitili alleviates dry season fodder shortages and prevents land degradation through reducing soil erosion and deforestation. The reserves provide a wide range of woodland goods - such as timber, fodder, fuelwood, medicinal herbs, wild fruits and honey. They help to enhance livelihoods, provide a vital safety net during dry seasons and droughts and generate additional income of up to US$ 500-1,000 per year and household. *Ngitili* greatly reduced women's labour, cutting the time spent on fuelwood collection by over 80%, and have a highly positive impact on biodiversity.

SLM measure	Management and vegetative
SLM group	Pastoralism and Rangeland Management
Land use type	Extensive grazing
Degradation addressed	Vegetation degradation; Decreased soil fertility; Loss of topsoil
Stage of intervention	Rehabilitation
Tolerance to climate change	Increased tolerance to climatic extremes (e.g. prolonged dry spells and droughts)

Establishment activities

1. Demarcation and closure of sites usually on degraded land around homesteads.
2. Total enclosure during up to 5 years for initial regeneration of vegetation (if land is degraded).
3. Establishment of tree nurseries to produce seedlings of native species.
4. Enrichment planting.
5. Removal of large trees (deterring grass growth), while protecting fodder trees.

Maintenance / recurrent activities

1. Closure of *ngitili* area at onset of rainy season. No management during rainy season.
2. Open area for grazing in July or August, after the crop residues and fallow vegetation have been depleted.
3. Temporary demarcation of paddocks for specific periods for rotational grazing within *ngitili* (controlled by experienced elders; based on utilisation level and fodder availability).
4. Controlled pruning and thinning (for firewood and poles).

Labour requirements

For maintenance: low
For establishment: low to medium (depending on the extent of enrichment planting)

Knowledge requirements

For land users: low
For advisors: low

Photo 1: Cattle grazing in a dry season fodder reserve. (Edmund Barrow)
Photo 2: Regeneration of trees has multiple benefits such a production of timber, fruit and honey. (Edmund Barrow)

Case study area: Shinyanga region, Tanzania

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	no data
Equipment	no data
Agricultural inputs	no data
TOTAL	**no data**

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour	no data
Equipment	no data
Agricultural inputs	no data
TOTAL	**no data**

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	very positive
Maintenance	slightly positive	very positive

Adoption

300,000-500,000 ha of woodland restored 1986-2001 (most of *Ngitilis* are individual, but area-wise half-half), over 800 villages; 60-70% of all households have *Ngitilis*.

Ecological conditions

- Climate: semiarid, unimodal rainfall
- Average annual rainfall: 600-900 mm; rainy season: October–May
- Soil parameters: medium to poor drainage; vertic soils are very extensive covering 47% of all soil types in the region
- Slopes: flat (0-2%) – gentle (2-5%)
- Landform: plains and hill slopes
- Altitude: 1,000-1,500 m a.s.l.

Socio-economic conditions

- Size of land per household: no data
- Type of land users: no data
- Population density: no data
- Land ownership: individual (cropland), individual / communal 50% / 50% (grazing land)
- Land use rights: individual / communal
- Market orientation: no data

Production / economic benefits

+++ Increased income (from selling timber / fuelwood; to purchase agricultural inputs, manpower)
+++ Increased wood production (timber, fuelwood)
+++ Increased fodder production (dry season!)
+++ Increased livestock production
+++ Reduced workload (collection of fuelwood / fodder by women)
+++ Increased production of non-timber forest products (fruit, honey, medicines, edible insects)

Ecological benefits

++ Biodiversity conservation / restoration (152 plant species; 145 bird species; also mammals returning)
+++ Vegetation regeneration / improved soil cover
+++ Reduced loss of top soil through erosion
++ Increased soil fertility
++ Increased water availability

Socio-cultural benefits

+++ Food security, diet diversification, improved health
++ Improved housing (thatched grass for roofs)
++ Improved education (school fees payment due to income from *ngitili*)
+ Income from communal *ngitili* used for village development (schools, health centres)

Weaknesses ➜ and how to overcome

- Damage to livestock and crops caused by growing wildlife populations ➜ outweighed by the benefits gained from *ngitili* (in most areas).
- Increased local inequity: benefit gap between richer and poorer households (who have no *ngitilis*); growing sales of *ngitilis* ➜ local institutions have to enable people to hold on to land and maintain *ngitilis*; allow poorer households to benefit from communal *ngitilis*.
- Scarcity of land, growing pressure (rising human and livestock populations); conflicts over grazing rights ➜ encourage villages to establish by-laws for protecting *ngitilis*.
- Insecurity of tenure impedes establishment of *ngitilis* (individual and communal) ➜ increase local people's and groups ownership and control over their resources; clearly acknowledge in national law the secure tenure of both private and communal *ngitili*.
- Productivity could still be improved ➜ introduction of improved fodder grasses. Planting of fast growing fodder trees and / or shrubs.

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COULOIRS DE PASSAGE - NIGER

The '*couloirs de passage*' are formally defined passageways which channel the movements of livestock herds in the agropastoral zones of Niger, by linking pastures, water points and coralling areas, be it within village areas (internal *couloirs*) or on open land (external *couloirs*). The main goal of the *couloirs* is the prevention of conflict between agriculturalists and pastoralists regarding the use of limited land and water resources. These conflicts are often provoked by cattle entering cropping areas.
The establishment of demarcated passageways allows the livestock to access water points and pastures without causing damage to cropland. The corridors are regulated through the '*code rural*' – a national law defining the land use rights of the pastoralists. Demarcation of *couloirs* is based on a consensual decision of all concerned interest groups. Internal *couloirs* are negotiated in a general on-site assembly involving all stakeholders (farmers, breeders, women's groups, local authorities). For the demarcation of external *couloirs* the involvement of transhumance herders and neighboring villages is indispensable.
Once an agreement on the course of the *couloir* is achieved, demarcation with stones and / or boundary planting with selected tree species is carried out by the local land users - with financial and technical assistance of the government or NGOs. Common species involve: *Euphorbia balsamifera, Acacia spp.* (*A. nilotica; A. senegal*); and *Faidherbia albida*. Management committees at the community level draw up regulations for the management of the *couloirs* (maintenance and protection of vegetation). Protection of plants is achieved through dead branches (at the initial stage), daily control by forest guards, and information campaigns. The technology is a sustainable solution to the described conflicts. As a valuable by-product the trees along the demarcation lines provide wood and non-woody by-products.

SLM measure	Management and vegetative
SLM group	Pastoralism and Rangeland Management
Land use type	Cropland or agropastoral (before), (silvo-)pastoral (after)
Degradation addressed	Soil erosion by water; Soil erosion by wind; Biological degradation; Primary problem addressed is conflicts between livestock and agriculture producers around natural resources
Stage of intervention	Prevention
Tolerance to climate change	Technology is sensitive to climatic extremes (such as droughts and floods)

Establishment activities

1. Identification of an existing *couloir* or definition of a new passageway by means of a general assembly (photo 1).
2. Alignment of corridor boundaries e.g. by establishing stone lines. Internal *couloirs* are 10 to 50 m wide, whereas external *couloirs* exceed a width of 50 m.
3. Digging 40 cm deep pits; tree planting along boundaries (with a spacing of 1-3 meters, depending on the species selected and the secondary objective) (photo 2).

Maintenance / recurrent activities

1. Protection of trees (through dead branches, guards, information campaigns).
2. Replanting tree seedlings to fill gaps (annually, beginning of rainy season).

Labour requirements

For establishment: low
For maintenance: low

Knowledge requirements

For advisors: high (facilitator of *code rural*)
For land users: low (pastors and workers)

Photo 1: Demarcation of a *couloir de passage* with two lines of Euphorbia seedlings. (LUCOP / Abdoulaye Soumaila)
Photo 2: A herd of small ruminants passing a well established *couloir*. (Fodé Boubacar Camara, PAFN)

Case study area: Tillabéri North, Niger

Establishment inputs and costs per km

Inputs	Costs (US$)
Labour: 25 person-days	38
Agricultural Inputs: 670 tree seedlings	1374
TOTAL	**1412**
% of costs borne by land users	5%

Maintenance inputs and costs per km per year

Inputs	Costs (US$)
Labour: 4 person-days	6
Agricultural inputs: 67 tree seedlings	137
TOTAL	**143**
% of costs borne by land users	100%

Remarks: The costs of the planning meeting (general assembly) and the stones for delimitation were not taken into account. Daily salary for field work is US$ 1.5. Costs for seedlings were calculated for a couloir length of 1 km and a spacing of 3 m between plants (one tree line on each side). Seedling production is financed by projects, only transport costs are met by land users.

Benefit-cost ratio

Inputs	short term	long term
Establishment	positive	very positive
Maintenance	positive	very positive

Remarks: Peace between communities is the key result in the short and long term. Ecological and economic benefits are linked to the plantation of trees and the improved management of natural resources.

Adoption

High growing spontaneous adoption (for prevention of conflicts and land degradation).

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 250-500 mm
- Soil parameters: sandy soils, with medium fertility, low soil organic matter and good drainage (low in case of soil crusting)
- Slope: mostly flat (0-2%)
- Landform: mainly plains / plateaus, valley floors
- Altitude: 0-100 m a.s.l.

Socio-economic conditions

- Size of land per household: 1-2 ha
- Type of land user: mainly poor; land user groups / community
- Population density: 10-50 persons/km^2
- Land ownership: mostly individual, titled
- Land use rights: individual, communal (organised)
- Level of mechanisation: animal traction
- Market orientation: mostly subsistence (self-supply), partly mixed (subsistence and commercial)

Production / economic benefits

+++ Increased crop yield
+++ Increased farm income
+++ Increased animal production
+++ Increased fodder quality and fodder production

Ecological benefits

++ Increased soil cover
++ Reduced wind velocity
++ Increased soil fertility
++ Increased biomass / above ground carbon
++ Reduced soil loss
++ Reduced fire risk
++ Increased animal diversity

Socio-cultural benefits

+++ Cultural benefits
+++ Conflict mitigation
+++ Community institution strengthening through mutual aid in technology implementation
+++ National institution strengthening (*code rural* secretariat)
+++ Improved cultural opportunities

Off-site benefits

+++ Reduced damage on public / private infrastructure
+++ Reduced damage on neighbours' fields
+++ Reduced wind transported sediments

Weaknesses ➜ and how to overcome

- Implementation constraints: plant production is very expensive and reaching a consensus on the transformation of private cropland to communal passageways is very difficult ➜ definition of the *couloirs* as public infrastructure and enhancement of organisational capacities of the local population through training and information sessions.
- Maintenance constraints: maintenance can only be realised by adjacent land owners, as the community organisations are weak ➜ reinforce the institutional capacities of livestock owners and farmers to manage the *couloirs.*
- In the pastoral zone the *couloirs* lead to conflicts between pastoralists and private ranches ➜ establish community-based land tenure commissions and introduce new laws on land property in the pastoral zone.

Main contributors: Abdoulaye Sambo Soumaila, Groupe de Recherche d'Etude et d'Action pour le Développement (GREAD), Niamey, Niger ; leffnig@yahoo.fr
Key references: Projet LUCOP/Tillabéry. 2004. Referential des measures techniques de recuperation, de protection et d'exploitation durable des terres, 2nd edition, 2004, 51 pp ■ Soumaila A.S. 2003. Base de données du code rural (online): www.case.ibimet.cnr.it/den/Documents/code_rural/start.html ■ Hiernaux P., E. Tielkes, E. Schlecht. 2001.Elevage et gestion des parcours au Sahel, Workshop proceedings organised by Eric Tielkes et Abdoulaye Soumaila, Verlag Ulrich E. Grauer, Beuren, Stuttgart, Germany, 2001

IMPROVED WELL DISTRIBUTION FOR SUSTAINABLE PASTORALISM - NIGER

Pastoralism, as practised in the case study area, is the traditional mode of extensive livestock husbandry, based on the movement of herds between the rich pastures in the northern pastoral zones (rainy season) and the southern areas (dry season) according to seasonal availability of water and grazing land / fodder (including residual vegetation of cropland). Both forms of pastoralism – nomadism and transhumance – are facing increasing water and fodder availability problems, due to a variety of reasons: change of climatic conditions, expansion of cropland, overstocking and overgrazing, amongst others. In view of these problems, the government of Niger has defined by law a pastoral zone, where crop production is limited to subsistence.

Within this area 'Pastoral Modernisation Zones' have been implemented, based on a new concept of semi-pastoralism to assure the sustainability of the pastoral land use system. Several practices are promoted at field level: improved distribution of water points, establishment of water harvesting structures, improved passageways for herds, improved fodder production, etc.

An optimal and efficient network / distribution of water points is a key element of modern sustainable pastoralism: it assures a balanced distribution of herds, and thus avoids overuse of vegetation around a limited number of wells. Since 1998, the number of traditional wells within the 3,000 km^2 of Akoubounou pastoral area has increased from 7 to 58. Construction is done by the local community – through trained well diggers. Support is provided by different development actors (government and NGOs). Well committees on community level are responsible for proper management of the wells. A fund for maintenance is established and is topped up through contributions of well users.

As a result of the improved well distribution, pastoral areas have been utilised in a more balanced manner, and overgrazing problems have been reduced by 30-40% compared to the situation in 1990.

SLM measure	Management
SLM group	Pastoralism and Rangeland Management
Land use type	Extensive grazing; Mixed (agro-silvo-pastoral)
Degradation addressed	Soil erosion by water; Soil erosion by wind; Biological degradation (overgrazing)
Stage of intervention	Mitigation and rehabilitation
Tolerance to climate change	Technology is sensitive to droughts and rainfall decrease

Establishment activities

Preparation:

1. Information and awareness raising campaign in village. Participatory planning (1-2 days).
2. Identification of sites by population, accompanied by field technicians
3. Formation and training of members of well management committee: laws, responsibilities, steering, evaluation, organisation, etc. (3-4 days).
4. Training of traditional sinkers (by external experts 1998-2000, then farmer-to-farmer training).

Establishment of well:

5. Dig well shaft: 0.8-1.5 m in diameter and 20-60 m deep (using pickaxe, shovel, bucket).
6. Install a scoop device (with cow leather or tire-tube; wire and poles).
7. Optional: Lining of the well shaft with stones / cement (e.g. if soil is not compact enough).
8. Build a wall with stones and cement around the well for protection (0.2-0.3 m wide, 0.5-1 m high).

Maintenance / recurrent activities

1. De-silting of wells (beginning of rainy season; May-June).
2. Reinforce walls of wells with cement (end of rainy season, October-November).
3. Deepen the well in case of descending groundwater level (dry season).
4. Constant monitoring of the wells by the Management Committee.

Labour requirements

For establishment: medium
For maintenance: medium

Knowledge requirements

For advisors: medium
For land users: low

Photo 1: One of the traditional wells that have been built to achieve a more balanced grazing throughout the pastoral area of Akoubounou.
Photo 2: Touareg family with a cattle herd in the pastoral zone during the rainy season.
Photo 3: Small ruminants around a traditional well during dry season. (All photos by Abdoulmohamine Khamed Attayoub / ADN)

Case study area: Akouboubou, Abalak, Tahoua region, Niger

Establishment inputs and costs per well

Inputs	Costs (US$)
Preparation (information campaign, planning, establishment of committee, etc.)	800
Construction of well (labour, equipment and material)	1,200
TOTAL	**2,000**
% of costs borne by land users	9%

Maintenance inputs and costs per well per year

Inputs	Costs (US$)
Labour, equipment and material	280
TOTAL	**280**
% of costs borne by land users	100%

Remarks: A management fund is established and managed by each well committee. Well users contribute annually, or each time maintenance work is needed. Amounts of contribution are not fixed but up to the individual, and generally proportionate to herd size. Committee can fine land users who damage the wells.

Benefit-cost ratio

Inputs	short term	long term
Establishment	positive	very positive
Maintenance	positive	very positive

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 300 mm; rainy season May-October
- Soil parameters: good drainage, in case of soil crusting low drainage, mainly low soil organic matter but high in swampy area
- Slope: mostly flat (0-2%)
- Landform: mainly plains / plateaus, valley floors
- Altitude: 0-100 m a.s.l.

Socio-economic conditions

- Size of land per household: < 1 ha
- Type of land user: community, mainly average level of wealth
- Population density: 9 persons/km^2
- Land ownership: mostly individual, titled
- Land use rights: individual, communal (organised)
- Market orientation: mostly mixed (subsistence and commercial)

Production / economic benefits

+++ Increased animal production
+++ Increased fodder quality and fodder production

Ecological benefits

++ Increased soil cover
+++ Increased soil fertility
+++ Increased biomass / above ground carbon
+++ Reduced soil loss
+++ Increased animal diversity

Socio-cultural benefits

+++ Conflict mitigation
+++ Community institution strengthening through mutual aid in technology implementation
+++ National institution strengthening (*code rural* secretariat)
+++ Improved cultural opportunities

Off-site benefits

+++ Reduced damage on public / private infrastructure
+++ Reduced damage on neighbours' fields
+++ Reduced wind transported sediments

Weaknesses ➜ and how to overcome

- High cost of implementation and maintenance ➜ active participation of pastoralists in establishment and maintenance activities; public investments; national funding system.
- Extinction of pastoral culture and traditional practices ➜ integrate pastoralists into structural transformation process; promote capacity building of pastoralists.

Adoption

The technology is well adopted in the case study area. 50 wells have been built in 12 years within a pastoral area of 3000 km^2. Implementation is based on incentives (establishment costs mainly paid by projects). However, there is a medium trend towards spontaneous adoption (by new actors).

Main contributors: Abdoulaye Sambo Soumaila, Groupe de Recherche d'Etude et d'Action pour le Développement (GREAD), Niamey, Niger; leffnig@yahoo.fr

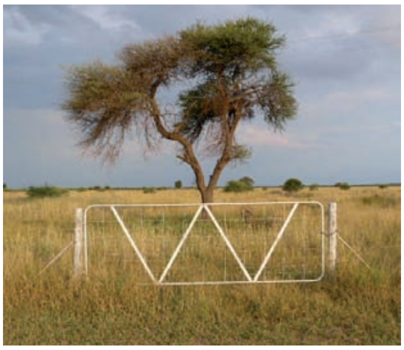
Key references: Soumaila A.S. 2003. Base de données du code rural (online): www.case.ibimet.cnr.it/den/Documents/code_rural/start.html ■ Hiernaux P., E. Tielkes, E. Schlecht. 2001. Elevage et gestion des parcours au Sahel, Proceedings de l'atelier organisé par Eric Tielkes et Abdoulaye Sambo Soumaila, Verlag Ulrich E. Grauer, Beuren, Stuttgart, Allemagne, 2001 ■ Project documents and annual monitoring reports of develpment projects by ADN Nourriterre and HEKS EPER Suisse (2003-2009) ■ Jochen Suchantke, Abdoulaye Sambo Soumaila (2001): Etude cadre pour le programme NIGETIP IV, KfW, Niamey, Niger, 2001

ROTATIONAL GRAZING - SOUTH AFRICA

Rotational grazing is a management system based on the subdivision of the grazing area into a number of enclosures and the successive grazing of these paddocks by animals in a rotation so that not all the *veld* (grazing area) is grazed simultaneously. Consequently, rotational grazing allows higher stocking rates than continuous grazing. The main principles of rotational grazing are: (1) Control the frequency at which pasture is grazed: adjustment of the rotation cycle ensures a good forage quality in each paddock. Pasture plants (including the most preferred and therefore overused species) are provided with a period of recovery or rest following grazing; (2) Control the intensity at which the pasture plants are grazed by controlling the number of animals which graze each paddock and their period of occupation; (3) Reduce the extent of selective grazing by confining a relatively large number of animals to a small portion of the *veld*: little opportunity for selection prevents domination of undesirable species.

Intensity of grazing should be adapted to the climatic conditions: in drier areas recovery periods should be longer due to limited plant recovery potential and high sensitivity to misuse and degradation. The ratio between periods of occupation and absence determines the plant yield and vigour: the shorter the period of occupation in a paddock the greater will be the yield of the *veld*: a second 'bite' is avoided and consequently the recovery period is at least equal to the period of absence. However, the shorter the period of occupation and the longer the period of absence, the greater is the number of paddocks required in a rotational grazing system.

Ideal resting periods vary with growth rate, and with the rate at which the *veld* loses its quality with maturity. Depending on the season, the climate and the use of irrigation, resting periods vary between 14 and 70 days, and even longer in the semi-arid grasslands (90–150 days). Appropriate stocking rates are assessed through 4 rating factors (defining the veld condition): species composition, basal cover, topography and soil erodibility.



SLM measure	Management
SLM group	Pastoralism and Rangeland Management
Land use type	Grazing land
Degradation addressed	Mainly biological degradation: reduction of vegetation cover, decreasing vegetation diversity
Stage of intervention	Prevention (partly mitigation and rehabilitation)
Tolerance to climate change	The technology is tolerant to climatic changes: land users can adjust grazing and resting periods according to changing conditions

Establishment activities

1. Farm planning: including technical design of farm plan with grazing paddocks, rotational system and livestock watering system conducted mostly by extension workers or specialists from Dept. of Agriculture.
2. Fencing.
3. Establishment of stock watering system including the construction of a dam, windmill, drinking trough, pipeline and borehole.

Maintenance / recurrent activities

1. Fencing.
2. Maintenance of windmill, pipeline, dam and drinking trough.
3. Implementing the system (moving livestock from one paddock to another, attend to livestock watering requirements (opening and closing of valves and attending to windmill brake on windy days).

Labour requirements

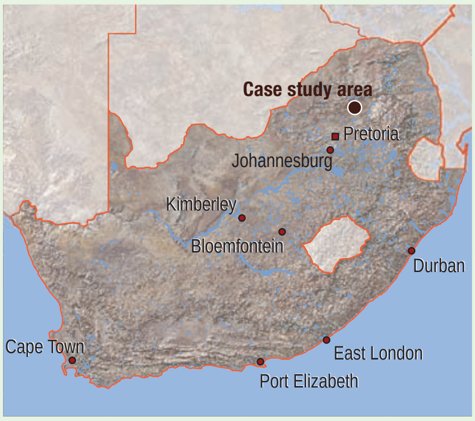
For establishment: medium
For maintenance: low

Knowledge requirements

For advisors: high (layout of the camps and design of stock watering and grazing system)
For land users: medium (implementation of the system, building of fences and stock watering system, maintenance)

Photo 1: Cattle drinking from a water trough near a windmill which pumps the water from a borehole into the dam or reservoir. From there drinking troughs are supplied. These have to be spread in a paddock to avoid local overgrazing.
Photo 2: Typical steel gate used in a rotational grazing system to allow access to and from grazing paddocks.
Photo 3: An example of a rested paddock (on the left) and a lightly grazed camp (on the right) with a barbed wire dividing the paddocks. (All photos by Lehman Lindeque)

Case study area: Crecy area, Springbokvlakte region, Limpopo Province, South Africa



Establishment inputs and costs per 500 ha

Inputs	Costs (US$)
Labour: 85 person-days	6,080
Equipment / tools: specify	1,160
Agricultural Inputs: specify	–
Construction material: specify	45,173
TOTAL	**52,413**
% of costs borne by land users	100%

Maintenance inputs and costs per 500 ha per year

Inputs	Costs (US$)
Labour: 32 person-days	3,173
Equipment / tools: specify	–
Agricultural inputs: specify	–
Construction material: specify	10,213
TOTAL	**13,386**
% of costs borne by land users	100%

Remarks: Estimated establishment time for a 500 ha farm with 8 paddocks more or less 6 months. The establishment and maintenance costs depend on farm size and the details of the farm plan / design of the paddock system including variables such as number of paddocks, number of stock watering points, number of boreholes, etc. Above mentioned costs are merely an indication for a typical livestock farm of 500 ha.

Benefit-cost ratio

Inputs	short term	long term
Establishment	very negative	positive
Maintenance	slightly negative	positive

Remarks: Establishment costs are very high and discourage many farmers from using a multi-paddock grazing system.

Ecological conditions

- Climate: mainly semi-arid, partly subhumid
- Average annual rainfall: 500 – 1,500 mm
- Soil parameters: shallow soils, medium soil organic matter, good to medium soil drainage / infiltration, soils with high fertility are used for cultivation
- Slope: 0-8 %
- Landform: plateau / plains and valley floors
- Altitude: 500 - 1000 m a.s.l.

Socio-economic conditions

- Size of land per household: 100-500 ha
- Type of land user: mainly large-scale commercial livestock farmers (large areas allow for many grazing paddocks)
- Population density: < 10 – 200 persons/km^2
- Land ownership: mainly individual not titled or partly communal village ownership
- Land use rights: mainly individual, partly communal organised
- Level of mechanisation: mechanised
- Market orientation: commercial

Production / economic benefits

+++ Increased fodder production (in available dry-material)
+++ Increased water availability / quality for livestock (through improved livestock watering systems)
++ Increased animal production (due to increased and better fodder)
++ Reduced risk of production failure
++ Increased farm income
++ Increased production area (due to better drinking water availability)

Ecological benefits

++ Increased soil moisture and reduced surface runoff
++ Reduced evaporation (through better plant cover)
++ Reduced hazards towards adverse events (floods, droughts, etc.)
++ Improved soil cover
++ Increased biomass / above ground carbon
++ Increased plant diversity and increased / maintained habitat diversity

Socio-cultural benefits

+++ Improved food security / self-sufficiency

Off-site benefits

+ Reduced groundwater and river pollution
+ Increased water availability (groundwater, spring)

Weaknesses ➜ and how to overcome

- Cost of construction or initial implementation ➜ convince farmers to see it as a long term investment to ensure sustainable production.
- *Veld* fires damage fences and drinking troughs ➜ prevent accidental *veld* fires by making fire bunds at the start of the dry season.

Adoption

Since 1994 rotational grazing is no longer subsidised by the government (subsidies restricted to small-scale communal and subsistence farmers). There is a moderate trend in adoption of the technology. Farmers realise the importance of vegetation management in sustainable livestock production, in view of the increasing pressure on grazing land and the risks of drought and climate change.

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Key references: Tainton N.M. 1988. Veld and Pasture Management in South Africa. Shuter & Shooter, Pietermaritzburg in association with University of Natal Press, Pietermaritzburg. ■ Department of Agriculture and Water Supply. 1989. Veld management in the Eastern Cape. Government Printer, Pretoria

SUSTAINABLE PLANTED FOREST MANAGEMENT

Protective pine plantations on degraded slopes and in gullies, Tanzania. (Hanspeter Liniger)

In a nutshell

Definition: Planted forests, or 'plantations', comprise trees established through planting seedlings and / or through direct seeding. Species may be native or introduced. Establishment may be on previously forested land or land that was not forest before. The purpose of planted forests can be either (1) commercial; or (2) for environmental / protective use; or (3) for rehabilitation of degraded areas. It may be a combination of more than one of these. The challenge is to develop planted forests that are financially viable as well as ecologically sustainable. The applicability and sustainability of planted forests depends on what they replace and how they are managed and harvested. Planted forests cannot act as a substitute for natural forests, they should rather complement and mutually reinforce the environmental and production services of the latter. In developing countries seventy percent of people depend on trees and forests as their major source of fuelwood. Due to declining supplies, planted forests are an increasingly important source of fuelwood and other forest products. Proper sustained management of planted forests is the only way to avoid shortages of wood and further deforestation of natural forests - planted forests lessen the need to log natural forests. However, there are very controversial opinions about the sustainability of planted forests, especially related to industrial large-scale monoculture plantations. On-going debate concerns whether planted forests constitute the best answer to the growing demand for wood, and whether they are an efficient way of 'carbon-offsetting'. In some situations planted forests can be excellent to rehabilitate degraded land, leading to improvements of the environment, whereas a similar plantation can have negative impacts elsewhere. A further key aspect is whether the mature trees are harvested, and if so, whether the stand is replanted (or left to coppice) or abandoned. It is at establishment and harvesting when most environmental damage can be done. Environmental guidelines need to be adhered to, or developed where inexistent.
Applicability: Planted forests with fast-growing species should only be established in areas with no water constraints.
Resilience to climate variability: Even small areas of planted forests (given the warning about water consumption above) can positively influence the microclimate, which can enhance the resilience to climate variability.
Main benefits: Rehabilitation of degraded areas (e.g. eroded or overgrazed areas), increased availability of wood products, fuelwood, and some non-wood forest products. They can lead to employment and income generation. There is reduced pressure on natural forests; planted forests are carbon sinks (unless they replace natural forests), especially on marginal agricultural land and degraded soils – and only if replanted / left to coppice after use.
Adoption and upscaling: Delineation of clear resource rights with respect to planted forests is essential. Research is important for scientifically based information about appropriate management, species compositions and the impact on the ecosystem. Capacity building and training should be provided to all stakeholders. Incentives may be needed for the establishment of planted forests, especially for the rehabilitation of degraded areas.

Development issues addressed	
Preventing / reversing land degradation	+++
Maintaining and improving food security	+
Reducing rural poverty	+
Creating rural employment	++
Supporting gender equity / marginalised groups	+
Improving crop production	na
Improving fodder production	+
Improving wood / fibre production	+++
Improving non wood forest production	+
Preserving biodiversity	+
Improving soil resources (OM, nutrients)	+
Improving of water resources	+/-
Improving water productivity	+
Natural disaster prevention / mitigation	++
Climate change mitigation / adaptation	++

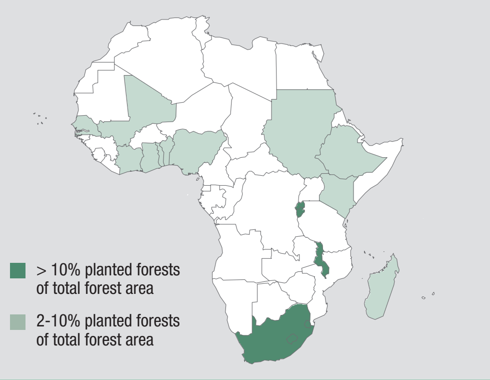
Climate change mitigation	
Potential for C sequestration (tonnes/ha/year)	1.2 – 2*
C Sequestration: above ground	+++
C Sequestration: below ground	++

Climate change adaptation	
Resilience to extreme dry conditions	+
Resilience to variable rainfall	++
Resilience to extreme rain and wind storms	++
Resilience to rising temperatures and evaporation rates	++
Reducing risk of production failure	+

**for the first 20-30 years of afforestation in drylands, depending on the selected tree species (FAO, 2004 and GTZ, 2009)*

Origin and spread in Africa

Origin: Large-scale plantation of exotic tree species in Africa originated during the colonial period with foreign investments and regulated by governments. Nowadays, there is a shift from previously government controlled management towards increased involvement of the private sector and small-scale producers. Since the 1960s, the emphasis has been maintained on fast-growing species primarily grown for supplying industrial wood (pulp and paper industry, fuelwood). In 2000, the total plantation area in Africa was 8,036,000 ha of which 42% are commercial-industrial plantations. Planted forests represent, only a very small fraction of the total forest cover in SSA (between 0.3% - 2.3% of the total).
Mainly in (more than 10% planted forests of total forest area): Burundi, Cape Verde, Lesotho, Malawi, Rwanda, Swaziland, South Africa.
Partly in (between 2-10% planted forests of total forest area): Benin, Ivory Coast, Ethiopia, Ghana, Kenya, Mali, Madagascar, Nigeria, Sudan, Senegal, Togo.
Plantation forestry is negligible in countries with large tracts of natural forests.



Spread of planted forests in SSA.

Principles and types

Technical aspects of sustainable planted forest management:
- **Sustaining soil fertility:** confining harvesting of forest products to stem wood, use of soil conservation measures, and application of fertilizer, etc.
- **Proper harvesting planning**, e.g. careful re-use of extraction routes.
- **Selection of species:** diversity of trees enhances resilience to pests and diseases and to climate variability / change.
- **Natural corridors** to enhance biodiversity especially of industrial plantations.
- **Fire breaks** to limit the extent of fires, often combined with access roads.

Planted forests vary from strictly protected conservation forests to highly productive, short rotation plantations. In this continuum the boundary between different categories is often indistinct.
Plantations for industrial purposes are mainly 'fast-wood' plantations, and are intensively commercially managed. They are usually blocks of single species producing round wood at high growth rates - often initiated with government support or through corporate investment projects. They may also have an environmental protection rationale. To be sustainable, industrial plantations should provide fair job opportunities, consider the environmental aspects of monoculture plantations, not be established on productive agricultural land nor replace natural forests. Commercial industrial plantations may also focus on the production of non-wood forest products (NWFP) such as gum arabic. There is a recent trend towards plantations to lock up carbon in 'carbon-offsetting schemes'. One risk is of farm land being taken out of production for this.
Out-grower schemes bring in private landowners (individuals / communities) into wood production. Forest companies are guaranteed a steady supply without being involved in land acquisition, whereas out-growers profit from employment opportunities and income. Out-grower schemes have potential to contribute to rural wealth creation, resulting in smaller and diverse production units.
Plantations for energy production form a main source of fuelwood in SSA. Most of these fuelwood plantations are within the public sector and the maintenance is often relatively neglected. For sustainable management clear land resource use rights must be given to land users.
Environmental / protective plantations have the purpose of protection and provision of environmental stabilisation. They can decrease soil erosion, stabilise slopes, fix sand dunes, serve as windbreaks, etc. Usually they are initiated with government support or project funding. Environmental plantations are gaining more importance with the increasing awareness of desertification.
Farm / home plantations and woodlots can provide a substantial amount of fuelwood and timber. Trees may be within an agroforestry system, homestead gardens or woodlots. Woodlands around small-scale farms can protect against shortages of fuelwood and construction poles, can be used for fodder production or for NWFPs, and have the potential to produce industrial wood.
Wood is the most important energy source in SSA, and the pressure on wood resources rises. Therefore farm plantations should be encouraged and alternative renewable energy resources (wind, solar) and energy-saving stoves promoted.




Top: Watering nursery seedlings for desertification control, Senegal. (Lyes Ferouki)
Middle: Eucalyptus plantation for timber and fuelwood production, Ethiopia. (Hanspeter Liniger)
Bottom: Environmental protective plantations on steep slopes, Eritrea. (Mats Gurtner)

Applicability

Land degradation and causes addressed

Biological degradation: loss of biodiversity in monocultures
Physical soil deterioration: little soil cover and undergrowth can lead to sealing and crusting
Chemical soil deterioration: loss of soil nutrients due to short rotations of industrial plantations
Soil erosion: especially in fast growing and high rotation industrial plantations with insufficient soil cover, and during establishment and harvesting phases
Planted forests can rehabilitate badly degraded land, helping to restore protective and environmental functions.
Planted forests which are under government tenure are very often poorly managed and financially not viable, leading to illegal logging and fires.

Land use

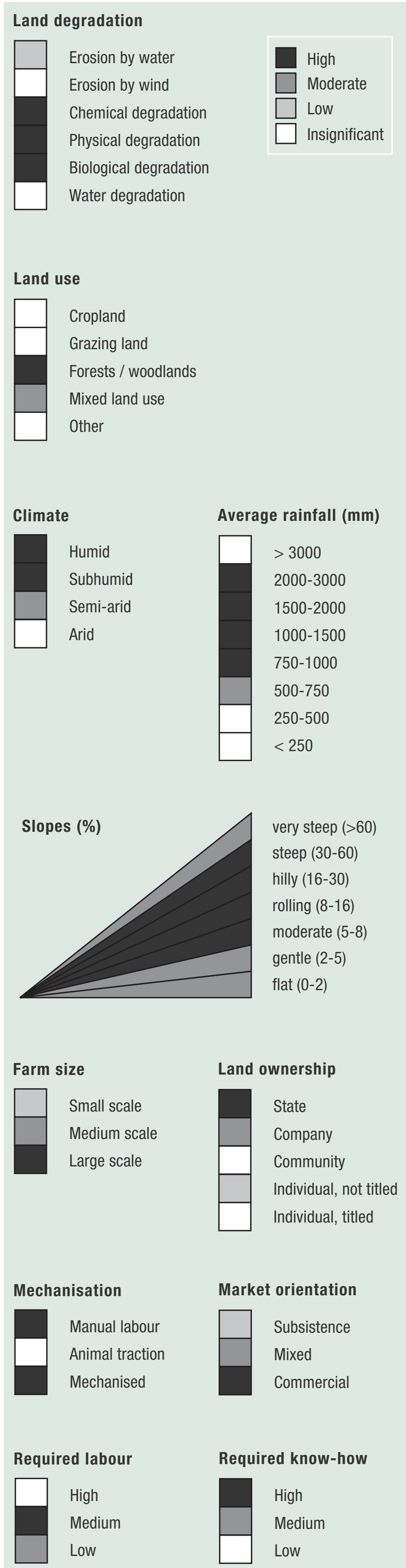
Mainly forest and mixed land.
The species planted vary in different regions; overall, conifers account for 52 percent, broadleaves for 37 percent, and unspecified for 11 percent. In order of importance the main coniferous genera by area are *Pinus, Cunninghamia, Picea, Larix* and *Cryptomeria* whilst the main broadleaf genera are Eucalyptus, Acacia, Tectona, and Populus species.
The majority of the trees are exotics with emphasis on short rotation plantations, only little emphasis on growing valuable indigenous trees due to slow growth rate and low economic return.

Ecological conditions

Climate: Humid zones emphasis on high value industrial plantations. Plantations used for commercial purposes are not suitable for water scarce areas due to restricted water availability for fast growing tree species and their ability to deplete already dry soils. In the dry zone (e.g. Sahelian region) planted forests are mainly for fuelwood production and for providing improved environmental conditions (e.g. sand dune stabilisation, windbreaks, etc.).
Terrain and landscape: There are terrain restrictions for planted forests related to very steep slopes and respecting riparian buffer zones.
Soils: No restrictions.

Socio-economic conditions

Farming system and level of mechanisation: Commercial fuelwood and environmental plantations are often owned and managed by the public sector: little mechanisation is involved. Large-scale industrial plantations are usually managed with a high degree of mechanisation – especially for harvesting. Farm plantations can be found in highly populated areas where not enough fuelwood from public forests is available.
Market orientation: Very large-scale commercial industrial plantations; plantations providing fuelwood and timber for subsistence and some commercial use; small-scale farm plantations for subsistence and some commercial use.
Land ownership and land use / water rights: Plantations are mainly owned by governments, partly by large industrial corporations and some by individual farmers. Industrial plantations in SSA are more than 50% publicly owned and about 34% privately owned. Non-industrial plantations are 62% publicly owned and 9% privately owned, and 29% are unspecified. In South Africa plantations are mainly owned by companies and small growers.
Skill / knowledge requirements: Theoretically a very high level of knowledge about the impacts of planted forests on the ecosystem is required.
Labour requirements: The establishment and the harvesting of large-scale plantations can be very labour demanding. Maintenance of farm plantations do not need much labour input.



Economics

Establishment and maintenance costs

Establishment costs: The establishment of a new forest usually implies very high initial investments, especially if established on a large-scale.
The extra investments for a management change from an 'old' planted forest system to 'sustainable management' does not involve very high 'establishment' costs. Those are mainly related to the development of a management plan, resource rights, regulations, etc.
Seedling production: 500 US$/ha
Land preparation, planting: ≈ 1,500 US$/ha
Maintenance costs: Tending, maintenance, pest and fire control: 600 US$/ha

Comment: It is very difficult to provide figures to the costs of planted forests. There are large differences by the type of planted forests, by initial conditions and by country.

Production benefits

Tree	Rotation length (year)	Productivity (m^3/ha/year)
Eucalyptus		
Congo	7	30
Rwanda	8	8.5
South Africa	8-10	18-20
Pines		
Malawi	20-25	17
Madagascar	15-18	6-10
Mozambique	18-28	11

(Source: FAO, 2001)

Comment: The figures above show the rotation length and the productivity of different commonly used tree species in planted forests.

Benefit-Cost ratio

Planted forests (by purpose)	short term	long term	quantitative
Industrial	–	++	Benefit-cost ratio at 10% discount ratio, Ghana: Teak: 4.9 (<10 ha) Cedrela: 3.5 (<10 ha) Pine: 1.8 (<10ha)
Energy production	– –	+	
Environmental	– –	– /+	
Farm plantations	–	++	

– – negative; – slightly negative; –/+ neutral; + slightly positive; ++ positive; +++ very positive
(Source: FAO, 2002)

Comment: Generally there is very limited data available related to the benefit-cost ratio of planted forests. However, the internal rate of return achievable with well-managed planted forests ranges between 5 and 20% depending on soil fertility, topography, species choice, growth performance, incidence of pests and fire and market prices for timber.
Efficiency in plantation management and success in achieving sustainable wood supply depends mainly on whether a plantation is publically or privately owned, and how it is managed. It is important here to distinguish between *financially* well managed plantations and *sustainably* managed. Usually, privately owned, forest plantations are well managed in financial terms - being aimed at profit maximisation. In Southern Africa it has been demonstrated that privately owned plantations can be profitable due to the integration of the plantation with wood processing companies. Many public sector plantations are poorly managed in financial terms being not profit oriented; however, often they have environmental and social benefits as objectives, which are not quantifiable.

Example: Industrial wood production by small farmers in the central highlands of Kenya
Economic analyses of cropping and tree enterprises have been carried out in some locations in the central highlands of Kenya. The average gross margin from trees per farm per year was Kshs 57,808 (US$ 734). This figure includes the contribution of coffee and tea, which was 65% of the total. Fruits contribute 28%, while timber and firewood contribute 8%. For 70-80% of the households the trees grown on farms function also as major sources of fuelwood. The remainder obtain their supply of firewood from neighbours or nearby forests. Following a temporary ban in 1999 on the sale of timber from government-owned forest plantations and natural forests, there has been an increase in the sale of timber from farms, and some farmers have formed associations to facilitate the marketing of timber. Accurate information on the profitability of this new timber enterprise is not available. However, the farmers also face many problems like lack of knowledge about tree management and market, permits needed for the felling and transport, etc. (Chamshama and Nwonwu, 2004).

Example: South Africa
Small-scale out-grower schemes in South Africa represent an investment of more than R 50 million (US$ 7 million), which should generate revenues of about R 175 million (US$ 24 million) for growers when the plantations are harvested. The small timber growers supplement their livelihoods with growing of food crops on the periphery of their woodlots. They make good profits and many have extended their operations from a single woodlot to three or four. Furthermore, the local community benefits from increased participation in the monetary market and from job opportunities created by the contracting by the companies of support services for planting, maintenance, harvesting and transportation. Small growers and rural communities also benefit from training programmes offered by the forest companies (Chamshama and Nwonwu, 2004).

Impacts

Benefits	Land users / community level	Watershed / landscape level	National / global level
Production	+++ increased availability of fuelwood + diversification of production + increased availability of NWFP	+++ reduced risk and loss of production +++ decreased pressure on natural forests + improved access to clean drinking water	+ improved food and water security
Economic	+ job creation (depending on the previous land use) + increased and diversified household income of small-scale land users (through farm plantations)	+++ less damage to off-site infrastructure ++ stimulation of economic growth ++ diversification and rural employment creation	+++ improve livelihood and human well-being
Ecological	++ improved soil cover ++ regulation of micro- and meso-climate ++ rehabilitation of degraded areas and restoring productive and environmental functions (e.g. due to over-grazing) ++ prevent soil erosion ++ used as windbreaks, shelterbelts, etc. ++ reduced pressure on farm manure ++ stabilisation of slopes, riverbanks, etc. ++ less nutrient mining than cropland + increased biodiversity + regulation of ground water (e.g. salinity) + increased soil organic matter and soil fertility	+++ reduced degradation and sedimentation + intact ecosystem	++ reduced land degradation and desertification incidence and intensity ++ increased resilience to climate change ++ carbon sequestration (when applied on degraded land / soil)
Socio-cultural	+/- can help to preserve the social and cultural values attached to forests + community institution strengthening	+ increased awareness for environmental 'health'	

	Constraints	How to overcome
Production	• Large-scale plantations are often monocultures	➜ mixed plantations, with intercropping, use of natural corridors to enhance biodiversity, etc.
Economic	• Lack of markets and access to markets • Establishment of plantations can be expensive and often rely on donor funding • Long time period between planting and harvesting of trees with no or only limited income (especially a problem in out-grower schemes) • Availability of fertilizers (e.g. phosphorous) • Availability of land and competition with other land use (e.g. demand for cropland and grazing land) and land grab for establishment of industrial plantations for wood or NWFP can lead to a loss of agricultural land affecting small-scale land users with no clear land tenure • Can increase pressure on natural forests by replacing tree diversity with monocultures that flood the market with cheap / fast growing wood.	➜ furthering the establishment of market and value chain ➜ credit schemes for small-scale land users to establish farm plantations ➜ providing of credits from timber companies ➜ support for small woodlots and farm plantations and regulations for new plantations, assessment of the economic, environmental and social sustainability of new forests, ensure land use rights for small-scale users and promotion of out-grower schemes
Ecological	• Exotic tree species can spread at the expense of native forests, affecting the entire ecosystem • Water need: fast growing species can have a very high demand of water and can have an irreversible negative impact especially in water scarce areas • Plantations can have high water use leading to lower streamflows, etc. and strongly influence the hydrological system of an area • Water competition with crops e.g. eucalyptus trees and limited availability of water in dry areas • Susceptibility of planted forests to pest and diseases especially in plantations • Monoculture plantations can damage the ecosystem	➜ appropriate selection of species ➜ considering the demand for water of the selected species, take into account sensitive and water scarce areas ➜ watershed management planning, considering off-site effects of plantations ➜ select less competitive tree species (e.g. *Grevilla robusta*) with a reduced water demand and high water use efficiency, manage trees by pruning ➜ diversification of species can remarkably reduce the risk to pest and diseases, maintaining optimum stocking levels
Socio-cultural	• Lack of know-how in management, species composition, improper establishment, etc.	➜ needs good training and education in the proper management of planted forests

Adoption and upscaling

Adoption rate

There is an increase in the area of planted forests in SSA, the annual rate of planting in Africa is estimated to be about 194,000 ha. However, the adoption rate for sustainable management of planted forests is not known and is rather difficult to assess, since a clear delineation of what is sustainable and what is not, is very difficult. The out-grower scheme has been adopted with great success in Southern Africa (especially South Africa, Swaziland and Zimbabwe).

Upscaling

Policy framework: Forest management must be integrated into a coordinated national framework with a clear forest policy. The forestry sector needs to be strengthened, and formulation and implementation of national and sub-national sustainable forest policies and programmes are necessary.
Land tenure: Publicly owned and managed plantations tend to display low productivity. Public bodies should seek the involvement of the private sector (smallholders, communities, companies, etc.) to support and encourage the efficient financial management of planted forests.
Capacity building: Capacity building and good training in sustainable management of planted forests is needed for all stakeholders involved (e.g. smallholders, communities and forests services, commercial users).
Research: More research is required about the impacts of planted forests on water resources (decreasing or increasing water availability) and on biodiversity, for a better understanding of the behaviour of different tree species, etc. Knowledge and expertise should be enhanced - related also to suitable indicators for monitoring planted forest resources.
Timber market: (1) Small-scale land users and communities need to be empowered by improving their access to markets and market information; (2) Certification of planted forests provides an opportunity but needs clear regulations and standards for declaration of the source of wood, and also considers social and ecological aspects. (3) Promotion of the out-grower scheme, as a successful way for private landowners to participate in wood production.
Farm plantations: The establishment of farm plantations should be further promoted and supported through an enabling policy framework and financial incentive packages for private investors. Farm plantations can strengthen the economic situation of land users as well as reduce the pressure on natural forests.

Incentives for adoption

Incentives for the establishment of new planted forests are very often needed due to the long period before economic benefit is gained. However, only those afforestation projects which are known to be ecologically and socially viable should be financially supported. Incentives for private tree planting and the establishment of farm plantations should be created, since they can provide fuelwood and other woody products and decrease the pressure on natural forests. For the creation of new large-scale planted forests, e.g. for rehabilitation of degraded areas, investments either from donors or from the government / public sector are needed, and the involvement of local communities should be guaranteed.

Enabling environment: key factors for adoption	
Inputs, material incentives, credits	+
Training and education	++
Land tenure, secure land use rights	+++
Access to markets	++
Research	+

Example: Ethiopia
The Government of Ethiopia has initiated collaborative plantation management programmes to address growing problems of illegal logging and forest encroachment by involving local communities. The government expects cooperation by allocating communities rights to establish and manage plantations for certain periods and by guaranteeing them a share in the profits from the timber. The guaranteed equal and fair profit-sharing agreements between state and community groups have attracted many smallholders to tree planting and can help strengthen the communities' commitment to sustainable forest management. Since the 1990s the government has increasingly granted community management rights favouring more community involvement in forest management, including planted forests, leading to some plantations allocated to communities. New regional land administration policies allow issue of landownership certificates to landholders, and owners have the right to lease their plots to others for up to 25 years; however, land still cannot be officially bought or sold (Nawir et al., 2007).

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CASUARINA TREE BELT FOR SAND DUNE FIXATION - SENEGAL

The *bande de filao*, a 200 m wide belt of *Casuarina equisetifolia* trees, was established along the Senegalese coast from Dakar to St.Louis, to protect the adjacent Niayes region from wandering sand dunes. The Niayes, a territory of 5-30 km width covering a surface of 4,200 km^2, is known for its favourable conditions for vegetable production. However, droughts, deforestation and overgrazing have caused gradual desertification and loss of stabilising vegetation cover on sand dunes. The dunes began to advance at a rate of up to 10-12 m per year and threatened villages and production areas.

The establishment of the tree belt started in the 1970s and continued until the late 1990s. The exotic nitrogen-fixing *Casuarina equisetifolia* was found to perfectly fit into the harsh ecological environment with its poor sandy soils, strong winds, shifting sand and proximity to the sea. Seedlings were raised in nurseries, then planted on a 2.5 x 2.5 m grid – protected by palisades and irrigated at the initial stage. The *filao* belt covers an area of about 9,700 ha and effectively halts wind erosion and movement of sand dunes, resulting in multiple positive impacts on the environment and the 120,000 people living in the area: it provides protection of villages, allowing vegetable production in inter-dunal depressions, and last but not least - builds up resources of wood. Without the tree belt, life in the Niayes would not be possible. Furthermore, wind speed was reduced also on the sea side, making inshore fishery possible during the whole year (before it was limited to 3 months).

The big challenge is to gradually replace the stands of *Casuarina* trees that have reached senescence (after approx. 30 years). A management plan has been developed to assure the continuity of this important protective system.

SLM measure	Vegetative
SLM group	Sustainable Planted Forests Management
Land use type	Forest (afforestation); Off-site land use: annual crops (vegetables) and fishery
Degradation addressed	Biological degradation: reduction of vegetation cover; Erosion by wind: loss of topsoil: uniform displacement, off-site degradation
Stage of intervention	Prevention and rehabilitation
Tolerance to climate change	Increased tolerance towards drought, floods, storms

Establishment activities

1. Initial protection with palisades (1 m high; 70 m from the coast; 1 year before planting).
2. Establish 0.5 m high palisades at a spacing of 10 - 20 m (depending on dune slope) perpendicular to wind direction; made of *Guiera senegalensis* on poles of *Euphorbia balsamifera* (before planting, November-June).
3. Enclosure: wire fence protects young plants from roaming animals.
4. Excavation of wells for watering of seedlings in nurseries and initial irrigation of the planted seedlings.
5. Production of seedlings in tree nurseries (January-February).
6. Plantations of seedling on a 2.5 x 2.5 m grid (1,600 plants/ha).
7. Guarding the plantation site (for protection of seedlings).

Maintenance / recurrent activities

1. Watering *filaos* during first year.
2. Guarding the plantation.
3. After 25-30 years replace the whole stand with new seedlings.

Labour requirements

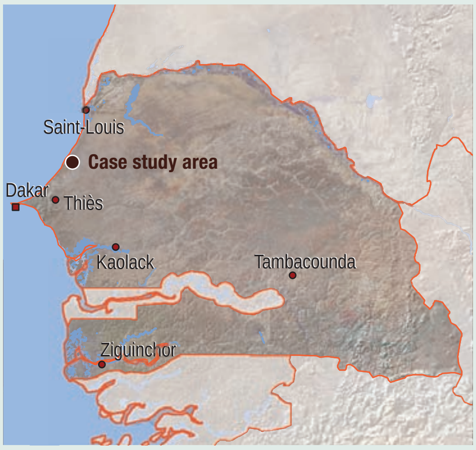
For establishment: high
For maintenance: low (maintenance is needed only in 1st year after establishment; if high inputs for replacing the whole stand after 25-30 years are taken into account, overall maintenance is medium)

Knowledge requirements

For advisors: medium
For land users: high

Photo 1–2: Tree plantation in Lompoul. (Julie Zähringer)
Photo 3: *Casusarina* seedlings ready for planting (front), establishment of palisades to protect planted seedlings (middle), and a *Casuarina* plantation aged seven years (in the background). (Mailly et al. 1994)
Photo 4: Areal view: the tree belt protects not only the settlements and vegetable production areas in the south-west, but also the inshore area of the Atlantic ocean, making fishery possible all year round. (Google)

Case study area: Lompoul, Niayes, Senegal



Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour	no data
Equipment	no data
Agricultural inputs: 1600 seedlings	225
TOTAL	**no data**
% of costs borne by land users	0%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour; Equipment; Agricultural inputs;	no data
TOTAL	**no data**

Remarks: Costs for establishment are high. All inputs were fully subsidised. Implementing agency was governmental 'Service des Eaux et Forêts' with funding from ACDI and USAID. Reestablishment starts after 25-30 years when trees reach senescence.

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	very positive
Maintenance	slightly positive	very positive

Remarks: Land users emphasise that without the technology they would not be able to live in this area.

Adoption

The *Casuarina* tree was established along the littoral between St. Louis and Dakar, covering an area of 97 km^2. Project support included provision of tree seedlings, technical assistance and rewarding labour. High establishment costs make a spontaneous spread of the technology difficult.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 250-300 mm
- Soil parameters: low soil fertility, low organic matter content (< 1%); sandy texture, good infiltration and drainage, low storage capacity
- Slope: no data
- Landform: sand dunes (slopes and interdunal depressions)
- Altitude: < 100 m a.s.l.

Socio-economic conditions

- Size of land per household: no data
- Type of land user: poor medium-scale land users; technology is implemented in groups / by community
- Population density: 65 persons/km^2
- Land ownership: state / individual (not titled)
- Land use rights: communal (organised)
- Level of mechanisation: manual labour / animal traction / mechanised
- Market orientation: mainly subsistence (forest land)

Production / economic benefits

+++ Increased wood production
+++ Increased production of litter used as mulch and for composting by vegetable farmers or by fishermen to smoke fish

Ecological benefits

+++ Reduced wind velocity
+++ Reduced soil loss
+++ Increased biomass
++ Increased soil organic matter / below ground carbon
++ Reduced hazard towards adverse events (drought, floods, storms)
++ Increased soil cover (with litter)
++ Improved carbon storage

Socio-cultural benefits

++ Increased recreational opportunities
++ Community institution strengthening

Off-site benefits

+++ Reduced wind transported sediments
+++ Sand dune stabilisation
+++ Improved vegetation cover
+++ Making establishment of settlement possible in the region
+++ Making horticulture possible in the region
+++ Making fishery possible all year round and therefore creating an additional income source
+++ Reduced damage on public / private infrastructure
+++ Reduced damage on neighbours fields

Remark: The technology focuses on off-site benefits!

Weaknesses ➜ and how to overcome

- High establishment costs for large scale plantations.
- *Casuarina equisetifolia* trees reach senescence after 30-50 years and do not regenerate naturally ➜ plantation activities need to be taken up again; In the hinterland reforestation with local *Cocos* should be tried.
- Increased demand for irrigation water.
- Making all year round fishery possible and therefore loosing labour force for vegetable cultivation.
- Increased amount of plastic waste (due to attraction of tourists).

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AFFORESTATION AND HILLSIDE TERRACING - ERITREA

Tree plantations in combination with hillside terracing to protect upper catchment areas are a widespread technology in the Central and Northern Highland Zone of Eritrea. In the early 1990s a large area was treated in the Toker catchment, northwest of Asmara. The first step was to establish hillside terraces on the steeper slopes where it is essential to conserve soil and water for improved growth of trees and other vegetation. The terraces comprise earthen embankments laid out along the contour, reinforced with stone risers, combined with a trench on the upper side to harvest runoff water. The trenches are subdivided into basins (by ties) to avoid lateral flow of runoff water. In a second step, trees were planted at a spacing of 2 m (in the trenches).
Mostly fast growing eucalyptus was used, with a very small percentage of the indigenous African olive (*Olea africana*) - which has good survival rates but grows very slowly. Afforested areas are closed for any use until the trees reach maturity: they are protected by guards. In 1995, the Ministry of Agriculture handed over user rights to communities allowing cut-and-carry of grass and cutting of trees (with permission of the government).
The technology requires appreciable expense, labor and expertise, but if maintained well, it results in multiple ecological and economic benefits: Soil cover has improved, water is conserved, the severe problems of soil erosion have been reduced, and dams further downstream are protected from siltation. Trees have become an important source of income for the rural communities, wood is a valuable resource mainly needed for construction, and also as fuel.
Since the 1960s, several afforestation campaigns have been initiated by the government, mainly using food-for-work or cash-for-work approaches as incentives. Nowadays, local tree planting initiatives (on community or individual level) without external support are dominant.

SLM measure	Vegetative and structural
SLM group	Sustainable Planted Forest Management
Land use type	Plantations, afforestation
Degradation addressed	Surface and gully erosion; Decline of vegetation cover, diversity and biomass; Loss of surface water; Lowering of ground water level
Stage of intervention	Rehabilitation
Tolerance to climate change	Sensitive to climatic extremes (e.g. rainfall decrease, especially in case of monocultures)

Establishment activities

1. Mark contour lines using a line level. Spacing between terraces depends on slope, vegetation status, soil depth. In the case study area horizontal spacing between terraces is 2.5 m.
2. Terraces are built (inward-sloping) by digging out trenches (0.5 m deep) and piling up risers (minimum 0.75 m high). Risers should be reinforced with stones (where available).
3. The trenches are separated into basins by ties at an interval of 2-5 m to avoid eventual lateral movement of water.
4. Dig planting pits (0.5 x 0.5 x 0.5 m), at 2 m intervals, in the trenches.
5. Plant tree seedlings (mainly eucalypts, some African olives); fill pit with top soil (optional: mix with 1 spade of manure).
6. Spot weeding and softening soil around the pits to improve percolation of water and soil aeration (during rainy season).
7. Supplementary irrigation during dry spells (using jerry / watering cans).
8. Prohibit open grazing. Area closure is done collectively.

All activities are carried out manually.

Maintenance / recurrent activities

1. Maintenance of structures (before onset of rainy season).
2. Replacement of missing plants at onset of rains (10% replacement of seedlings is expected in the 1st year).
3. Spot weeding and softening soil.
4. Supplementary irrigation.

All activities are carried out manually.

Labour requirements

For establishment: high
For maintenance: low

Knowledge requirements

For advisors: medium
For land users: high

Photo 1: Construction of hillside terraces: trees will be planted in the ditches at a spacing of 2 meters between plants. (Fikreyesus Ghilay)
Photo 2: An upper catchment area protected by hillside terraces and tree planting in the Central Highlands of Eritrea. (Mats Gurtner)

Case study area: Serejeka, Central Highlands, Eritrea

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour: 660 person-days	1,760
Equipment / tools: hand tools	50
Agricultural inputs: seedlings and transportation	600
Construction material: stones (locally available)	0
TOTAL	**2,410**
% of costs borne by land users	73%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour: 180 person-days	480
Equipment / tools: specify	0
Agricultural inputs: seedlings and transportation	100
TOTAL	**580**
% of costs borne by land users	83%

Remarks: Labour costs include construction of hillside terrace, pitting, planting and spot weeding and cultivation. According to the work and payment norms of the Ministry of Agriculture the cost of 1 person-day is US$ 2.66. Production cost of one seedling is US$ 0.2. Maintenance costs include terrace maintenance, re-pitting and replanting of seedlings. Costs are calculated for gentle slopes with terraces spaced at 2.5 m.

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly negative	very positive
Maintenance	neutral	positive

Remarks: Initial labour inputs payout on the long term.

Ecological conditions

- Climate: semi-arid
- Average annual rainfall: 400 -450 mm
- Soil parameters: low fertility; shallow depth; low organic matter content; sandy-loam texture
- Slope: more than 50%
- Landform: hill slope, mountain slopes, ridges
- Altitude: 2,300 - 2,400 m a.s.l.

Socio-economic conditions

- Socio-economic conditions
- Size of land per household: 0.5-1 ha cropland and 0.01-0.05 ha forest land
- Type of land user: small-scale, poor, land user groups
- Land ownership: state
- Land use rights: communal (organised)
- Level of mechanisation: manual labour and animal traction
- Market orientation: subsistence (self-supply), partly mixed (subsistence and commercial)

Production / economic benefits

+++ Increased wood production
+++ Increased fodder production (cut-and-carry of grass)
+++ Diversification of income sources (selling timber and grass)

Ecological benefits

+++ Improved soil cover; increased biomass / above ground carbon
+++ Reduced surface runoff
+++ Reduced soil loss
++ Increased soil moisture
++ Increased soil organic matter
++ Recharge of ground water

Socio-cultural benefits

+++ Community institutions strengthened
+++ Improved food security / self sufficiency
+++ Improved conservation / erosion knowledge
++ Conflict mitigation
+ Increased recreational opportunities

Off-site benefits

+++ Reduced downstream flooding and siltation
+ Increased stream flow in dry season

Weaknesses ➜ and how to overcome

- Establishment cost is high and labour-intensive ➜ provision of hand tools and demanded seedlings.
- Fast growing eucalyptus trees have a high rate of water consumption; Indigenous trees are not favoured ➜ encourage people to protect naturally regenerated indigenous trees, assist villagers to get market channels for products of indigenous trees.
- Community mobilisation and high knowledge of land users is required ➜ awareness raising campaigns, strengthen village institutional arrangements, assist villages by-laws.
- Land use rights: because the afforestation area is communal, nobody feels responsible for maintenance ➜ promote plantations by individual households.

Adoption

Acceptance of afforestation areas has increased, since user rights have been given to land users: Communities located in Toker upper catchment areas have taken the initiative to maintain and protect their woodlots. Moreover, there is a trend toward locally initiated hillside terracing and tree planting without external initiative / incentives, apart from the provision of seedlings (through Ministry of Agriculture). The afforestation area covers approx. 30 km^2 with high potential to enlarge.

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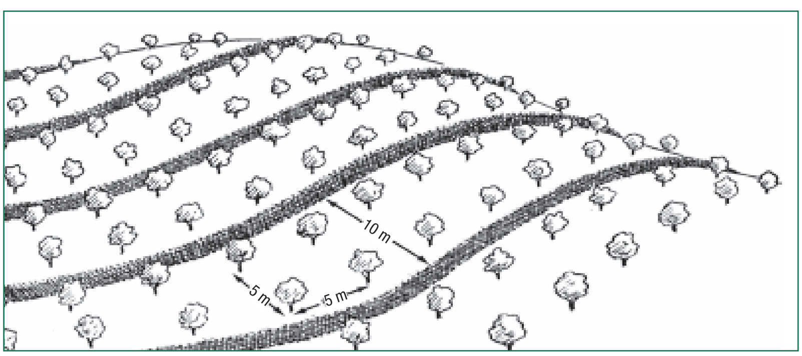
SAND DUNE STABILISATION - NIGER

Stabilisation of mobile sand dunes is achieved through a combination of mechanical measures including palisades, and biological measures such as live fences and sowing of grass. These measures seek to stop sand encroachment and stabilise sand dunes on-site, in order to protect villages, cultivated land, roads, waterways and other infrastructure. The technology is currently applied on a very large-scale in the Niger river basin.

Palisades are made either of millet stalks, or doum or date palm fronds, according to availability in the region. They are established in a perpendicular direction to the wind, at a spacing of 10 – 20 meters depending on severity of sand encroachment and level of land degradation. The closer the spacing, the more effective is the protection. Tree seedlings or cuttings are planted on a 5 m x 5 m grid, with a density of 400 trees per hectare. Species include *Euphorbia balsamifera*, *Prosopis chilensis*, *Ziziphus mauritiana*, *Acacia senegal* and *Bauhina rufescens*. Grass seeds are broadcasted.

The increasing speed at which desertification is progressing in Sahelian countries makes this technology one of the main instruments for combating the impacts of climate change. Land that has been sown with grass needs to be enclosed in the early years to avoid interference by animals.



SLM measure	Structural and vegetative
SLM group	Sustainable Planted Forest Management
Land use type	Agro-silvopastoral
Degradation addressed	Desertification; Soil erosion by wind and water; Biological degradation
Stage of intervention	Prevention (partly mitigation)
Tolerance to climate change	Tolerant to temperature increase and rainfall decrease, but sensible to droughts and floods

Establishment activities

1. Preparation of tree cuttings or seedlings.
2. Preparation of palisades made either of millet stalks, *Leptadenia pyrotechnica*, or doum or date palm fronds, according to availability in the region.
3. Marking of planting lines perpendicular to wind direction.
4. Preparation of soil (April-May): dig holes for the cuttings or seedlings.
5. Dig trenches for the palisades.
6. Set up the palisades (spacing: 10 m).
7. Transport cuttings or seedlings to the sites.
8. Planting of cuttings or seedlings (spacing: 5 m).
9. Sowing of grass.
10. Spreading of manure (for grass and trees).

Maintenance / recurrent activities

1. In the first years: weeding and protection against animals, maybe using enclosure of land that has been sown with grass seeds.
2. Replacing of missing plants.
3. Strengthening of palisades and replacing those that have been destroyed.
4. Regular trimming of trees and shrubs to reduce competition with agricultural crops.

Labour requirements

For establishment: high
For maintenance: high

Knowledge requirements

For advisors: low
For land users: moderate

Photo 1–2: Palisades with growing vegetation.
Photo 3: Two SLM experts examine a sand dune in the Niger river basin near Niamey. (All photos by Moussa Inja).
Drawing: Layout of palisades and tree planting for sand dune stabilisation. (Ministry for Agricultural Development, Niger)

Case study area: Kareygorou, Tillabéry, Niger

Establishment inputs and costs per ha

Inputs	Costs (US$)
Labour: 75 person-days	113
Palisades: 1,000 bundles	200
Agricultural inputs: - Seedlings / cuttings (400) - Organic manure (1.5 t)	 80 75
Transport: palisades, seedlings and organic manure	200
TOTAL	**668**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour: 10 person-days	15
Palisades: 15 bundles	3
Agricultural inputs: seedlings (20)	4
TOTAL	**22**
% of costs borne by land users	100%

Remarks: Figures are based on estimates. Costs for seedlings / cuttings are indicated for *Euphorbia balsamifera*. For other tree species costs need to be doubled or tripled (higher production costs at the nursery).

Benefit-cost ratio

Inputs	short term	long term
Establishment	positive	very positive
Maintenance	positive	very positive

Remarks: The technology is efficient in the mid to long term when it supports natural regeneration of ecosystems. In the Niger River basin, however, the benefits are lower.

Ecological conditions
- Climate: semi-arid
- Average annual rainfall: 250-500 mm
- Soil parameters: good drainage; low soil organic matter
- Slope: high dunes with steep slopes (> 20%)
- Landform: mainly dunes
- Altitude: 0-100 m a.s.l.

Socio-economic conditions
- Size of land per household: 1-2 ha
- Type of land user: mainly poor land user groups / community
- Population density: 10-50 persons/km^2
- Land ownership: mostly individual, untitled
- Land use rights: individual, communal (organised)
- Market orientation: mostly subsistence (self-supplying), partly mixed (subsistence and commercial)
- Level of mechanisation: manual labour

Production / economic benefits
+++ Increased crop yield (indirectly; through protection from moving sand dunes)
+++ Increased farm income
+++ Increased animal production
+++ Increased fodder quality and fodder production

Ecological benefits
+++ Increased soil cover
+++ Increased biomass / above ground carbon
+++ Reduced wind velocity
+++ Reduced soil loss
+++ Increased animal diversity
++ Increased soil fertility

Socio-cultural benefits
+++ Conflict mitigation
+++ Strengthening of community institutions through mutual help with technology implementation
+++ Improved cultural opportunities

Off-site benefits
+++ Less damage on public / private infrastructure
+++ Less damage on neighbours' fields
+++ Less wind-transported sediments

Weaknesses ➜ and how to overcome
- Implementation constraint: high implementation costs ➜ improve access to technical and financial support.
- Maintenance constraint: the nature of the land discourages people from maintaining the established measures ➜ establish management committees for maintenance of the implemented measures.
- Labour constraint: the technology requires high input in terms of labour ➜ strengthen community work and solidarity between communities.
- Ecological constraint: negative impacts on existing *Leptadenia* plants due to excessive cutting for palisades ➜ find other species for making the palisades.
- Legal constraint: conflicts arise when land is claimed by people ➜ define tenure before land is claimed.

Adoption
Spontaneous adoption of the technology is growing because desertification is in progression and sand dunes endanger people's livelihoods.

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SUSTAINABLE FOREST MANAGEMENT IN DRYLANDS

Natural dryland forest with high biodiversity, Tanzania. (Hanspeter Liniger)

In a nutshell

Definition: Sustainable Forest Management (SFM) in drylands aims to ensure that the goods and services derived from the forests meet present-day needs, while at the same time securing their continued availability and contribution to long term development.
In Sub-Saharan Africa, forests and trees contribute significantly to rural livelihoods in the drylands accounting for more than 25% of rural household income. Forests have multiple functions and uses. They play a significant role in conservation of biodiversity adapted to the harsh ecological conditions. They provide ecosystem goods including fruits, gum arabic, shea nut (*karité*) butter, fodder for livestock, medicines and provide services such as desertification control, conservation and improvement of water quality. However they are relatively fragile and easily affected by drought, erosion, fires, browsing, and particularly, cutting for firewood. Forestry needs to be part of a comprehensive and sustainable land use planning and management strategy, and there is an urgent need for the forestry sector to show clear commitment and to work with other sectors in improving and designing appropriate policies and mechanisms. In addition SFM in drylands has to move towards participatory and community-based management with an integrated landscape planning approach.
SFM in drylands includes actions aimed at safeguarding and maintaining the forest ecosystem and its functions, reduced deforestation, fire management, restoration through natural regeneration or assisted natural regeneration, selective tree planting and felling. Main techniques used for sustainable management are: spatial zoning for various users, restricted interventions, protective measures, best practice in non-wood forest products harvesting, grazing management planning and improved governance.
Applicability: SFM is applicable to, and crucial for, any type of primary or secondary forests in the drylands.
Resilience to climate variability: SFM for forest diversity is a prerequisite to ensure a functioning ecosystem, and to maintain resilience to climate variability and change. A well-managed and diverse natural forest can adapt better to changes.
Main benefits: Protection of biodiversity, protection against water and wind erosion, improved water management and quality, improved livelihoods and human well-being through income diversification (e.g. beekeeping, ecotourism, etc.) and hence increased food security and poverty alleviation as well as improved governance. Hindering further deforestation and expanding the restoration of natural forests can provide an immense contribution to CC mitigation and adaptation.
Adoption and upscaling: A legal and institutional framework, including the integration of forests in overall sustainable landscape and rural development planning is needed in order to ensure a sustainable use of forest resources in drylands, and sustainable provision of the related social, economic and environmental goods and services.

Development issues addressed	
Preventing / reversing land degradation	+++
Maintaining and improving food security	+
Reducing rural poverty	++
Creating rural employment	++
Supporting gender equity / marginalised groups	++
Improving crop production	+
Improving fodder production	++
Improving wood / fibre production	++
Improving non wood forest production	+++
Preserving biodiversity	+++
Improving soil resources (OM, nutrients)	+++
Improving of water resources	++
Improving water productivity	++
Natural disaster prevention / mitigation	+++
Climate change mitigation / adaptation	+++

Climate change mitigation	
Potential for C Sequestration (tonnes/ha/year)	no data
C Sequestration: above ground	++
C Sequestration: below ground	++

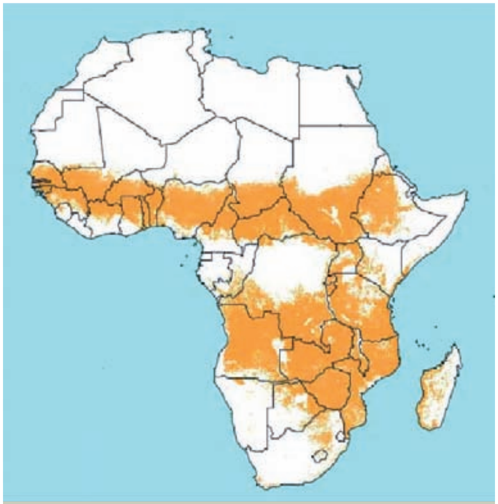
Climate change adaptation	
Resilience to extreme dry conditions	++
Resilience to variable rainfall	+++
Resilience to extreme rain and wind storms	+++
Resilience to rising temperatures and evaporation rates	++
Reducing risk of production failure	+++

Origin and spread

Origin: The sacred character of many forests helped to conserve them, as part of traditional community resource management systems. Forest degradation and deforestation began during the colonial era. Responses to degradation of forests also started during these times. As pressure on forests has increased, because of population growth, efforts were made to create protected forest areas. In the 1970s and 1980s many countries - with donor support - attempted to bring more forests under state tenure and protection. In recent times sustainable forest management based on community plans has been given increasing priority in the drylands of SSA. Successes are still only at the pilot stage.

Spread: 582 million ha are covered by forests in SSA of which 270 million ha (46%) are dry forests. Approximately 5% of Africa's forests are protected. However, protected areas are often still destroyed by illegal logging and overuse. No clear data is available about the spread of SFM in drylands, but it is only a very small area.

Dry forests are mainly situated in: Angola, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, DRC, Ethiopia, Gabon, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Senegal, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia, Zimbabwe.



Spread of dry forests in SSA. (Source: CIFOR, 2006)

Principles and types

Securing forest resources: National and local forest authorities need to be strengthened to assess, maintain and protect the remaining forest resources. Protected areas must be safeguarded through adhering to laws and regulations for effective management. The delimitation of forests should be made clear, and sufficient cropland made available to people neighbouring the forests. Simultaneously, productivity of cropland and grazing land need to be improved to reduce pressure on the natural forests. Plans must correspond to the ecological, economic and social concerns of the people living within and around the area: thus community-based approaches and management plans are the most promising way forward. Compensation to communities – ideally through judicious rights to forest products - can be considered as a means for ensuring sustainable use of the resources.

Maintaining or enhancing biodiversity: Building better knowledge of forest ecology can help to preserve their biodiversity. Capacity needs to be strengthened to conduct biological inventories and a monitoring system of forest condition. There is also a need to include fauna within the forest in management decisions.

Promoting healthy and vigorous forests and rehabilitating forests: The health of overused forests can be improved through the adoption of adaptive forest management, including aspects such as review of rotation length, enhancement of natural regeneration (e.g. social fencing), enrichment planting, selective felling and controlled logging. Upgrading species diversity and richness are also a means to improve 'forest productivity', and to ensure high value production in a well managed natural forest.

Fire management: Knowledge and awareness raising about fire (incidence and behaviour) and how to avoid uncontrolled fires is key in successful prevention. Lack of funding and of sustainable fire management strategies are prominent in SSA. Fire management is largely an agricultural issue, and therefore the key is to involve the agricultural sector in the controlled use of fire. Monitoring and reporting mechanisms should be established, and the regional collaboration that started through AfriFireNet should be built upon.

Alternative livelihoods options help reduce unsustainable felling and logging activities. Non-wood forest products (NWFP) provide a sustainable input to peoples' welfare. NWFP can be honey from beekeeping, mushrooms, medicinal plants, shea nut butter (from *Vitellaria paradoxa*) for the cosmetic industry, gum arabic (from *Acacia senegal*), baobab for ropes and baskets, etc. New niche markets for 'green' and 'fair trade' products and payments for ecosystem services provide new income opportunities for forest users (see group Trends & new Opportunities).

Top: Fencing of dryland forests for natural regeneration, Burkina Faso. (NewTree)
Middle: Women carrying gathered fuelwood, Senegal. (Roberto Faidutti)
Bottom: Close-up of shea nuts (karité) ready to be processed, Burkina Faso. (Roberto Faidutti)

Applicability

Land degradation and causes addressed

Dryland forests are fragile and are affected by drought, degradation / deforestation and desertification. The main direct and indirect drivers include: population increase, growing demand for resources (grazing, cultivation, urban development, logging, etc.), poverty, social conflict, lack of market opportunities, no recognition of the importance of dryland forests, lack of appropriate policies, governance and investment, lack of integration among different sectors, lack of technical capacity etc. All these drivers are potentially exacerbated by climate change.

Biological degradation: loss of forest ecosystem, loss of biodiversity, followed by physical and chemical soil deterioration and water degradation.

The loss of natural forests in the drylands is immense and the trend still continues. Annual loss of natural forests - between 1.2% and 1.7% - is highest in West and Southern Africa.

Land use

Primary and secondary forests can be defined as natural forests. Dry forests cover a spectrum of vegetation types from deciduous forests with a continuous tree canopy to moist savannas, dry deciduous woodlands, dry savannas and very dry scrub (bush, brousse). Dry forest landscapes are very variable, with crop lands, grazing lands and woodlands existing side-by-side.

Dry forests are used as mixed land for agricultural production and grazing. Beside wood products such as fuelwood and building material, non-wood forest products used are honey, mushrooms, fruits, medicinal plants, spices, shea nut butter, gums, fodder, tree bark, etc.

Ecological conditions

Climate: scarce and unreliable rainfall with long dry spells; dryland forests cover arid, semi-arid and subhumid areas.

Terrain and landscape: no restrictions, however in many countries (e.g. Ethiopia) forests have been reduced to marginal areas like steep hills, etc.

Soils: no restrictions

Socio-economic conditions

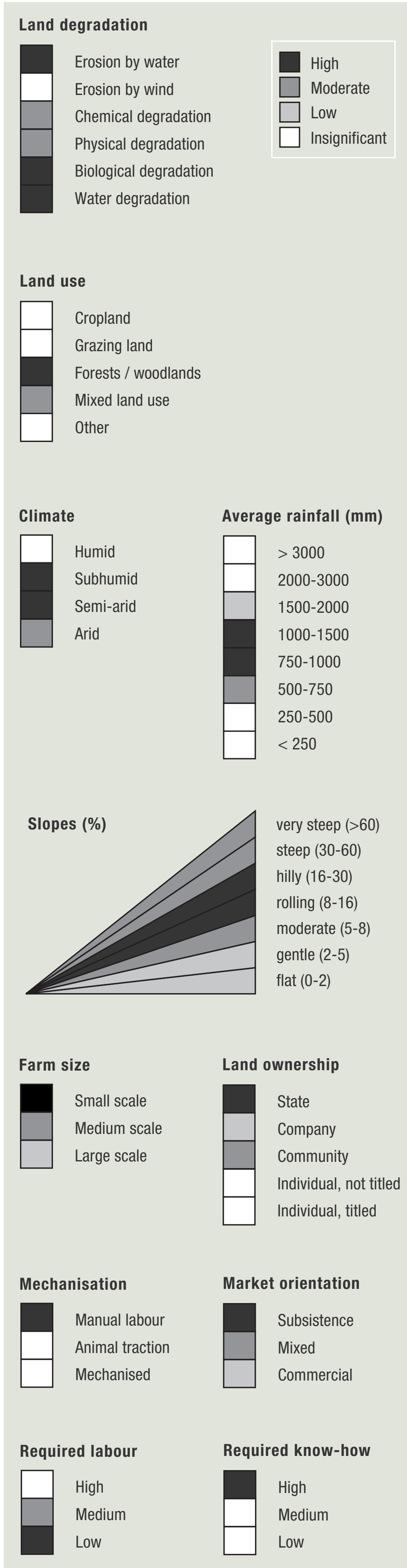
Farming system and level of mechanisation: Sustainable management mainly on small-scale basis, mainly manual labour (e.g. hand felling) and low level of mechanisation.

Market orientation: Subsistence to commercial system, by selling non-wood and or wood products on local market and also for increasing national / global market for special high value niche products.

Land ownership and land use / water rights: Land ownership is mainly state: some forests are on customary and trust lands, and may be managed through agreements with the chiefs or local councils on behalf of communities. Forests on private land are very limited with exceptions in South Africa and Zimbabwe. The areas of forests jointly managed with local communities or under the full responsibility of local communities are very limited. Open access forests and woodlands give rise to problems with destructive forest resource use.

Skill / knowledge requirements: Sustainable forest management requires a high level of technical knowledge. Sound education of forest management services for supporting the land users in the sustainable use of the forests resources is needed.

Labour requirements: Labour requirements vary depending on the interventions needed (see principles and activities).



Economics

Costs

Since Sustainable Forest Management (SFM) is mainly a management and organisational issue, the assessment of costs for establishment and maintenance is limited.

Production benefits

Apart from wood, natural forests provide a huge variety of products (non-wood forest products), which makes it difficult to quantify the production benefits of sustainable management in dryland forests. Recent studies are helping to put a price on the full range of forest goods and services. However research is needed on the value of environmental services such as water quality and supply, soil retention and fertility, carbon storage, and conservation of biodiversity, among other aspects. Furthermore, methodologies are required to calculate the direct or indirect cost of unsustainable forest management for comparison.

Benefit-Cost ratio

	short term	long term	quantitative
Community based forest management	–	++	No data available

– – negative; – slightly negative; –/+ neutral; + slightly positive; ++ positive; +++ very positive;
(Source: FAO, 2002)

An estimated 65% of the population of Sub-Saharan Africa is rural and depends directly or indirectly on forests and woodlands for food, fuelwood, building materials, medicines, oils, gums, resins and fodder. The World Bank estimates that forests generate at least 20% of the disposable income of landless and poor families (WFSE, 2009).

Communities must be willing and economically able to involve themselves in sustainable forest management - they must receive greater economic benefits from conserving forests than from degrading them. Sustainable natural forest management should tangibly improve local economic welfare, and generate local economic benefits to sufficient levels, and in appropriate forms, to make SFM economically sound in the drylands also.

Since SFM is not yet widespread in SSA, it is difficult to make a realistic assessment of the economic aspects of natural forest management and the probability of change to sustainable management during the next two decades.

A mechanism for Reducing Emissions from Deforestation and Degradation (REDD), currently under negotiation, may provide incentives to reduce emissions from forests.

Example: Burkina Faso

The Kaboré Tambi National Park is situated approximately 100 km south of Ouagadougou in the south-central part of Burkina Faso, and covers 155,000 ha. Nine villages surrounding the park were surveyed, and 298 households completed a survey in 2008. Land cover in the park mainly consists of open forest with patches of savanna. The contribution of non-timber forest products to the rural household income was analysed. Fuelwood is the most important product collected from the forest: it accounts for 28% of household environmental and forest income on average. Fruits and shea nuts from Vitellaria paradoxa are the second most economically important wild forest product in the survey area (21%). Grass for roof thatching is another important non-timber forest product in the region, contributing 14% of household environmental and forest income. While fuelwood and thatching grass are mostly used for subsistence at the household level (86% and 84%), shea nuts and fruits are mainly source of cash income (66%) (CIFOR, 2008).

Example: Making Shea butter, Ghana

The production of shea butter is an important income earning activity for women in rural areas. Shea trees (Vitellaria paradoxa) grow wild in the semi-arid parts of the equatorial belt of central Africa. Shea butter is made out of the kernels and is used for cooking and for cosmetic purposes. The butter is increasingly valuable as an export commodity. However, lack of group business and management skills, competition from large-scale enterprises, inflation, and international commodity price fluctuations may hinder successful implementation of the technology. Bridge presses can now be used to mechanically extract shea butter and reduce the workload needed as they are easy to operate. The presses can be locally made and serviced. Although costs of processing by the improved and traditional methods are comparable, the benefits of the new technology are environmental (no need for fuel), time-saving (releasing time for other activities) and process simplification. However, the profitability of the shea butter production depends very much on high market prices (TECA-FAO, 2010).

Impacts

Benefits	Land users / community level	Watershed / landscape level	National / global level
Production	++ diversification of production ++ enhanced long term forest productivity ++ increased production of NWFP + increased wood production	+++ reduced risk and loss of production + improved access to clean drinking water	+ improved food and water security
Economic	++ provides a wide range of wood and non-wood products ++ income diversification + increased farm income	+++ less damage to off-site infrastructure ++ diversification and rural employment creation (e.g. eco-tourism) + stimulation of economic growth	+ improved livelihood and well-being
Ecological	+++ improved protection of forest species and habitats +++ rehabilitation of natural forests +++ improved micro-climate +++ biodiversity enhancement ++ helps to maintain soil and hydrological systems (e.g. clean water) ++ reduced soil erosion (by wind / water) ++ reduced wind velocity and dust storms ++ less frequent uncontrolled forest fires ++ increased soil organic matter and soil fertility ++ improved forest cover + improved water availability	+++ reduced degradation and sedimentation ++ water availability ++ water quality ++ intact ecosystem	+++ reduced degradation and desertification incidence and intensity +++ increased resilience to climate change ++ reduced C emissions ++ increased C sequestration ++ enhanced biodiversity
Socio-cultural	+++ community institution strengthening ++ less conflicts among different users ++ improved SLM / conservation / erosion knowledge	+++ increased awareness for environmental 'health' +++ attractive landscape ++ reduced conflicts	+++ protecting national heritage

	Constraints	How to overcome
Production	• Restricted short-time use ('exploitation') of forests can have negative effect on income	➜ awareness of long term benefits and increase of other valuable ecosystem services provided through natural forests
Economic	• Inadequate budget for fire management • Availability of market for non-woody products and ecotourism	➜ integration of fire management into overall forest management plan ➜ support the diversified production and establishment of markets for NWFP and ecotourism
Ecological	• Impossibility of reconstituting forests exactly as they were	➜ promote the role of secondary forests and allow most suitable conditions for regeneration towards natural forests
Socio-cultural	• Increasing population leading to increased demand on fuelwood • Fire management: weak capacity and social and political environments that do not sufficiently enable or empower the affected population to deal with the fire problem • Political constraints: secure land tenure of communities is often not given and regulatory constraints, with modern and customary laws that are often in conflict • Poverty leading directly to indiscriminate extraction of forest resources • Knowledge is inadequate, scattered and poorly disseminated in many of the spheres involved in sustainable forest resource management • Lack of knowledge in terms of appropriate techniques to ensure sustainability and on the current state of forest resources	➜ promote alternative renewable energy resources (wind, solar) and energy saving stoves, establishment of home woodlots ➜ allocation of land use rights as well as training and education in fire prevention and management ➜ allocation of land use rights and consolidating / harmonisation of legal situation including customary laws ➜ supporting poor communities in and around forests to improve their livelihoods and make them independent from destructive forest use, introduce alternative income options through non-woody forests products (e.g. beekeeping) or ecotourism ➜ compilation and exchange of experiences made with SNFM, learning from others and capacity building of both government staff and community members ➜ better linkages to research and regular monitoring and reporting about state of natural forests

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Adoption and upscaling

Adoption rate

The adoption rate of SFM in drylands tends to be very slow, and despite various efforts, sustainable management is not in place in most countries. However, in some areas of dry forests of savanna woodlands, progress has been made in this regard. Most of these areas are under community control.

Upscaling

The following aspects need to be considered for adoption and upscaling:

Legal and institutional framework: Integration of forest planning in an overall sustainable landscape planning approach, including all sectors from agricultural, pastoral, urban / rural and forest systems, is needed. Government and local administration must create enabling conditions for the establishment of proper SFM frameworks with clear regulations and control mechanism.

Legal titles, or at least confirmed land-use rights, are a prerequisite for villagers to define their forests boundaries and for community-based forest management.

Community-based approaches: Communities must be enabled to establish a clear management plan. Clear regulations and control mechanism need to be developed by forest services and local communities for the sustainable use of forests, and to avoid illegal use of the forests.

Awareness raising, education and capacity building: Local forestry services, land users and communities should be appropriately trained. Improved understanding of forestry issues through stakeholder meetings, user-friendly materials, documents in local language etc. is needed. It is necessary to become organised, coordinate efforts, share information and develop campaigns so that the governments adopt enabling policies, and to make sure people are informed about benefits of SFM.

Inventories and long term monitoring: Knowledge and expertise should be enhanced to assess and monitor forests and tree resources systematically.

Research related to SFM: This includes better knowledge of forest pests and diseases, and conditions related to adoption and upscaling, as well as better linkages to research institutions and networks for knowledge exchange.

Sustainable markets and networks for NWFP: So far there are many obstacles hindering the commercialisation - especially of NWFP of small-scale land users. The development of forest-based small enterprises and the establishment of local markets can enhance small-scale production of NWFP and hence reduce the pressure on timber harvesting. Priority should be given to strengthening the capacity of local producers of forest products, processors and traders, to ensure sustainable harvesting and management of forest resources while increasing the quality and added-value of the derived products.

Incentives for adoption

Micro-credit to establish small industries (e.g. for NWFP) can help build incentives towards better SFM. Furthermore, incentives are needed to bridge the time until trees become productive (e.g. for areas under natural regeneration). Recent discussions and development promote Payment for Ecosystem Services (PES) as an incentive for sustainable management. Clear commitment is needed to pay for the maintenance of the remaining forest resources.

Enabling environment: key factors for adoption	
Inputs, material incentives, credits	+
Training and education	++
Land tenure, secure land use rights	+++
Access to markets	++
Research	++
Infrastructure	+
Conflicts of interest	++

The Network for Natural Gums and Resins in Africa (NGARA) *was established in May 2000 to assist African producer countries and partners in formulating a co-ordinated strategy for the sustainable development of their natural gums and resin resources in order to improve rural livelihoods and environmental conservation. NGARA brings together members from varied fields, including farmers / collectors, traders, governments, non-governmental organisations, exporters and importers – all of whom have the common desire to improve the production and quality of locally produced gums and resins for domestic, regional and international markets. NGARA consists of 15 member countries. Since inception, NGARA has played an increasingly important role in the exchange of information on production and trade, training, technology transfer, assessment of resources and their sustainable use, enhancing capacities of stakeholders in beneficiary countries and harnessing efficient use of available resources by strengthening synergies. The establishment of NGARA was considered a significant step in the development of the gum arabic and resins sector in the dryland Sahel for ensuring food security, rural development and hence poverty alleviation (www.ngara.org).*

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ASSISTED NATURAL REGENERATION OF DEGRADED LAND - BURKINA FASO

Assisted natural regeneration, as promoted by newTree in Burkina Faso, starts with enclosing 3 ha of degraded land with a solid fence. Fence materials (iron posts and galvanic wire) are externally sponsored and locally assembled and installed. Along the fence a dense living hedge of thorny trees (local tree species: e.g. *Acacia nilotica*, A. *senegal*, *Prosopis* sp, *Ziziphus mauritiana*) is planted. A strip of 10 m along the hedge is dedicated to agriculture. This area is equivalent to approximately 10% of the protected area. The rest is dedicated to natural regeneration of the local forest.

Once protected, natural vegetation rich in endogenous species can actively regenerate. Annual vegetation species inventories are made to monitor the biomass, biodiversity and the growth rate of the trees. The forest reaches a tree density of approximately 500 trees per hectare and consists of around 120 local species. Some enrichment planting of rare species enhances the allotments. The protected area is of paramount importance for biodiversity conservation.

Management activities in the protected area includes (1) seeding / planting of improved fodder species; and (2) establishing stone lines and half-moons (*demi-lunes*) for soil erosion control and water harvesting, (3) installing beehives for honey production; and (4) fodder production: the grass is cut, tied and carried to feed livestock outside the regeneration area.

Property rights for the protected area are clearly established through a contractual agreement that includes / respects traditional and government land rights. The local land users select the area, provide all labour inputs and ensure the long term management of the sites according to mutually agreed goals. Training is provided to enhance income generating activities – ranging from beekeeping and the production of high-value vegetable crops to the processing of non-timber forestry products – and to promote the use of fuel-efficient cooking stoves.

SLM measure	Management and vegetative
SLM group	Sustainable Forest Management in Drylands
Land use type	Before: Agro-silvopastoralism, wastelands; After: Agroforestry / Natural forest
Degradation addressed	Soil erosion by water and wind; Fertility decline; Sealing and crusting; Reduction of vegetation cover; Aridification
Stage of intervention	Rehabilitation
Tolerance to climate change	High tolerance

Establishment activities

1. Select an area of 3 ha of degraded land.
2. Establish a 1.5 m high fence around the selected area: install metal posts, manufacture / assemble chain-link fence materials (manually).
3. Plant a living hedge of spiny trees at a distance of 1 m to the fence, plants spaced at 0.4 m.
4. Reserve a 10 m strip along the fence / hedge for improved agriculture.
5. Plant a living hedge of *Jatropha curcas* to separate cropland from regeneration area.
6. Seed / plant improved fodder species within protected area.
7. Establish stone lines and half-moons for soil erosion control and water harvesting within protected area.
8. Install beehives (2-10 hives per protected area); purchase protection and harvesting equipment.
9. Construct fuel efficient cooking stoves.

Maintenance / recurrent activities

1. Supervise fence and protected area; repairing where necessary.
2. Replant / replace dead seedlings in living hedges.
3. Improved agriculture: agroforestry, water harvesting, compost application.
4. Beekeeping: monthly control of beehive; yield 2-3 times per year (manually with protection equipment).
5. Improved fodder production: cut grass and tie hay with simple tying machine (once a year after rainy season).

Labour requirements

For establishment: high
For maintenance: medium

Knowledge requirements

For advisors: medium
For land users: medium

Photo 1: The components of the system (from right to left): Metal fence, living hedge (recently planted seedlings), agricultural zone with SLM measures (e.g. agroforestry), forest regeneration area.
Photo 2: Fabrication of chain-link fence by land users.
Photo 3: Dense vegetation cover in the protected area behind the fence. (All photos by Franziska Kaguembèga-Müller)

Case study area: Soum Province; Burkina-Faso

Establishment inputs and costs for 3 ha

Inputs	Costs (US$)
Labour	1,300
Equipment / tools: pick, shovel, hammer, glove, tong, iron rod	100
Agricultural inputs: training, seeds, compost	260
Components for fence construction: sand, gravel, rock and water, poles, galvanised wire, cement, tree seedlings	2,900
TOTAL	**4,560**
% of costs borne by land users	33%

Maintenance inputs and costs for 3 ha per year

Inputs	Costs (US$)
Labour	730
Training	40
Agricultural inputs: seeds	40
TOTAL	**810**
% of costs borne by land users	95%

Remarks: A unit relates to a protected area of 3 hectares (average size; feasible and beneficial for participating land users, namely farm families / womens' groups). Labour for establishment includes: digging of planting pits / ditches, post installation, fabrication of chain-link fence materials, all plantations, stone lines, half-moons, etc. Components for fence construction are locally available.

Benefit-cost ratio

Inputs	short term	long term
Establishment	neutral	very positive
Maintenance	positive	very positive

Ecological conditions

- Climate: arid, semi-arid
- Average annual rainfall: 300 - 600 mm per year
- Soil parameters: soils are often very poor and overexploited; laterite
- Slope: mostly flat 0-2%
- Landform: mainly plains / plateau
- Altitude: 0-100 m a.s.l.
- Altitude: 2,300 - 2,400 m a.s.l.
- NewTree works in 2 different climatic zones with different ecological conditions

Socio-economic conditions

- Size of land per household: 3 ha
- Type of land user: small-scale, very poor or poor, implementation by families (up to 60 members) or groups (e.g. women's groups)
- Population density: 30 persons/km^2 in the Nord, 70 persons/km^2 in the centre
- Land ownership: state (officially); traditional family property rights (factually)
- Land use rights: families

Production / economic benefits

+++ Increased wood production
+++ Increased farm income and diversification of income sources
++ Increased fodder quality and quantity
++ Increased crop yield

Ecological benefits

+++ Increased biomass / above ground carbon
+++ Increased soil organic matter / below ground carbon
+++ Improved soil cover
+++ Increased nutrient cycling / recharge
+++ Increased plant diversity / habitat diversity
+++ Improved harvesting / collection of water
+++ Reduced soil compaction and crusting
++ Reduced surface runoff / soil loss
++ Increased beneficial species (predators, earthworms, pollinators)
++ Reduced evaporation
++ Reduced wind velocity
++ Increased soil moisture

Socio-cultural benefits

+++ Improved food security / self-sufficiency
+++ Improved health
++ Improved conservation / erosion knowledge
+ Improved situation of socially and economically disadvantaged groups

Weaknesses ➜ and how to overcome

- High investment costs ➜ introduce income generating activities which amortise (help pay off) the initial investments and the waiting time until land users can harvest non-woody products from the forest; relocate the fence to enclose other degraded land when the living hedge is dense enough and takes over the function of protection.
- Insecurity of land rights is a constraint for implementation (government is official land owner) ➜ conclude contractual agreements which include / respect traditional and government land rights.

Adoption

All land users have implemented the technology through receiving incentives (payment for labour and other inputs). Regeneration sites have been established in 5 different provinces (Soum in the North, Kadiogo, Kourweogo, Boulkiemde and Oubritenga in the centre of Burkina Faso). There is high demand for establishment of further sites. The demonstration effect of improved agriculture within the fence (agroforestry, etc. resulting in higher yields) encourages farmers to adopt these measures in their fields outside the protected area also.

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INDIGENOUS MANAGEMENT OF TAPIA WOODLANDS - MADAGASCAR

For centuries, the population of the highlands of central and south-western Madagascar has sustainably managed and conserved the local tapia woodlands. These woodlands play an important economic role as a source of non-timber forest products (NTFP) such as wild silk, fruit, mushrooms, edible insects, and herbal medicines. Tapia trees (*Uapaca bojeri*) comprise up to 90% of all trees in these woodlands, bear an edible fruit, and their leaves nourish an endemic silkworm (*landibe*). *Landibe* silk is used to produce ritual burial shrouds throughout the highlands. Trading silk products and tapia fruits is a crucial source of cash income for the local communities.
The tapia woodlands are maintained by the local villagers through burning and selective cutting. Burning favours the dominance of pyrophytic (fire-tolerant) tapia trees and protects silkworms from parasites. Selective cutting of non-tapia species and pruning of dead branches also favours tapia dominance and perhaps growth. Other common species include the endemic *Sarcolaena eriophora* and the invasive *Pinus patula / khasya*. The tapia woodland is clearly an anthropogenically shaped forest. However, the creation and maintenance of the woodlands should be seen as positive transformation rather than a form of degradation.
Local and state-imposed regulations protect the woodlands from overexploitation. The Forest Service has placed restrictions on forest cutting and burning while allowing for traditional use rights. The collection of forest products is regulated through a type of common-property regime. For example, fuelwood collection is limited to dead trees or fallen branches. It is forbidden to break off large branches to access cocoons. Thanks to these protective regulations, forest boundaries are mostly stable, and woodland density has increased in several cases.

SLM measure	Management
SLM group	Sustainable Forest Management in Drylands
Land use type	Natural forest; silvopastoralism
Degradation addressed	Reduction of vegetation cover; Quantity biomass decline
Stage of intervention	Prevention and mitigation
Tolerance to climate change	Silk and fruit harvests vary from season to season but drivers are poorly understood (could include precipitation and temperature)

Establishment activities

The management of the tapia woodlands has evolved over centuries and in recent times has been supported by state imposed regulations. Thus no establishment activities can be listed here.

Maintenance / recurrent activities

1. Selective cutting of non-tapia species, especially invasive pines.
2. Pruning of dead branches.
3. Controlled burning mainly through understory fires after the rainy season (January-May).
4. Collection of non-wood forest products such as fruits (September-December), medicinal plants, mushrooms, berries, insects, and hunting of mammals etc.
5. Collection of *landibe* silkworm twice a year (November-December and May-June). The cocoons are cooked, spun and woven into silk fabric.
6. Collection of fuelwood, limited to dead or downed wood.

Labour requirements

For establishment: na
For maintenance: low

Knowledge requirements

For advisors: na (traditional practice)
For land users: low (children often harvest fruit; silk cocoon harvest is easy)

Photo 1: Typical tapia woodland south of Antsirana.
Photo 2: Tapia woodland with some invasive pine trees bordering highland rice fields.
Photo 3: Small late wet season fire in a tapia woodland.
Photo 4: *Landibe* wild silk cocoon.
Photo 5: Bags of tapia fruit for sale on the side of the road.
(All photos by Christian Kull)

Case study area: Antsirabe and Ambositra, Col des Tapia, Madagascar

Establishments inputs and costs per ha

Traditional method; no establishment phase and costs.

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour: 10 person-days for harvest of NTFP	20
Equipment / tools: specify	0
Agricultural inputs: specify	0
Construction material: specify	0
TOTAL	**20**
% of costs borne by land users	100%

Remarks: The estimation of costs is difficult - fruit are gathered over a two month period by school children going out for an hour in the early morning each day; the silkworms are collected by individuals (usually experienced collectors) on free days. In some areas, projects exist that run silkworm nurseries, establish firebreaks in the woodlands, grow and plant tapia seedlings, and finance the purchase of silk looms. These projects obviously require much larger budgets.

Benefit-cost ratio

Inputs	short term	long term
Establishment	na	na
Maintenance	positive	positive

Remarks: The larger rainy season silk harvest provides crucial cash income during the meagre months before the rice harvest. In 1998, the price of 200 cocoons was between US$ 0.10-0.15. For a basket of tapia fruits villagers earned between 0.02-0.06 US$/kg. During the harvest the tapia woodlands produce about 4 kg of fruits per ha (= US$ 0.1-0.25/ha). Dependence upon woodlands for cash income varies from 0-40%.

Ecological conditions

- Climate: subhumid; 7 months of dry season
- Average annual rainfall: 1,000 – 1,500 mm
- Soil parameters: mostly nutrient-poor or rocky soils; low organic matter; high drainage; rockier, silica-rich soils compared to the main lateritic soils of highland Madagascar
- Slope: hilly to steep (20-80%)
- Landform: hill slopes
- Altitude: 800 - 1,800 m a.s.l.
- Tapia woodlands are short, endemic, sclerophyllous formations, resembling-Mediterranean oak forests or southern Africa's Miombo woodlands.

Socio-economic conditions

- Size of land per household: na (woodlands are communal)
- Population density: 20-40 persons/km^2 in the central highlands and 10-20 in the western highlands
- Type of land user: mainly small-scale, poor households
- Land ownership: state
- Land use rights: communal (organised)
- Level of mechanisation: manual labour
- Market orientation: subsistence (self-supply) and mixed (subsistence-commercial)

Woodlands are officially state-owned, but in practice managed by neighbouring communities (either unofficially, or increasingly through community-based management contracts).

Production / economic benefits

++ Increased cash income (through selling silk-fabrics and other NTFP)
+++ Production of NTFP as important dietary supplements (berry, mushrooms, protein (insect), etc.)
++ Stable supply of fuelwood
++ Provisioning of medicinal plants

Ecological benefits

+++ Maintenance of biomass,
++ Maintenance of soil cover and regulation of soil loss
++ Maintenance of endemic biodiversity

Socio-cultural benefit

+++ Improved food security / self-sufficiency (different forest products)
+++ Maintained cultural value (sacred forest)

Weaknesses ➜ and how to overcome

- Partly individual indiscriminate cutting and / or strong use of fires leads to overuse of the forest resources ➜ needs clear regulations, guidelines and observation of the rules by the local authorities as well as awareness raising about the multiple benefits of the forests.
- Invasion of exotic tree species such as pine and eucalyptus from private and village woodlots ➜ the forest service has rightly been encouraging communities to cut these trees from the tapia forests without the need for complicated permits.
- Insecure land use rights ➜ in 1996 a new legislation opened the way to officially decentralise management of state-owned renewable natural resources to adjacent communities, which would aid woodland protection by increasing stakeholder involvement.
- In some areas, silkworm populations have been very low for decades ➜ recent projects seek to establish silk nurseries and reintroduce the worm.

Adoption

This system of woodland management is applied in almost all endemic tapia woodland areas. The area of these woodlands is 2,600 km^2 (study area: approx. 50 km^2), affecting perhaps 100,000 people. It is a traditional practice – no incentives necessary.

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SUSTAINABLE RAINFOREST MANAGEMENT

Rainforest as natural habitat for mountain gorillas, Rwanda. (Hanspeter Liniger)

In a nutshell

Definition: Sustainable Rainforest Management (SRFM) in tropical and mountain areas aims to ensure that the goods and services derived from natural forests meet present-day needs while at the same time securing their continued availability and contribution to long term development. Central Africa contains the world's second largest area of rainforests and shelters some of the greatest biological diversity within the continent, and thus plays a vital role in global ecological services. Yet, illegal logging, agriculture and hunting seriously threaten the diversity and values of these forests. In many countries rainforests are now restricted to mountain areas, and to coastal and river areas. Mountain forests in particular play a crucial role in providing freshwater resources, and feeding rivers and groundwater tables which provide life to dry lowlands.
SRFM combines political and technical issues. On the political side, despite clear commitments of governments and local administrations (ratification of conventions, laws / regulations, etc.), effective measures for protection and sustainable management of the remaining natural forests must be better implemented at ground level. One major issue is improving country level integrated and participatory land use planning with a better recognition of the need for land tenure and customary rights to be afforded to the local populations. On the technical side, there are two main aspects: the protection and maintenance of undisturbed forest areas for conserving its rich biodiversity, and the sustainable management of forests for productive purposes either commercially or under a subsistence system, in other words how to balance profitability while still maintaining ecological and social integrity. Some critics say that conservation of biodiversity is not compatible with any use of the forests. However, for most of the population living in, or around, rainforest areas the use of forest products represents a vital means for food security. New trends and opportunities such as paying for ecosystem services should be further assessed and supported. This provides a promising solution to better integrate conservation and economic aspects.
Applicability: Applicable and crucial for any type of natural primary or secondary rainforests in tropical and mountain areas.
Resilience to climate variability: Rainforests are a common resource pool and how well the forest is maintained will determine how vulnerable community livelihoods and national development will be to climate change impacts.
Main benefits: Improved livelihoods and human well-being through income diversification and salaries from industrial forest sector, improved water availability since mountain rainforests are water towers for dryland areas, maintaining an ecosystem with rich biodiversity; hindering further deforestation can contribute immensely to the global carbon balance, providing a critical buffer against global climate change.
Adoption and upscaling: Success of SRFM depends on the establishment of policies based on poverty reduction and the active involvement of various stakeholders at the local, national, regional and international levels. Furthermore it requires financial resources, a political will, and social investment.

Development issues addressed	
Preventing / reversing land degradation	+++
Maintaining and improving food security	+
Reducing rural poverty	++
Creating rural employment	+
Supporting gender equity / marginalised groups	+++
Improving crop production	na
Improving fodder production	+
Improving wood / fibre production	++
Improving non wood forest production	+++
Preserving biodiversity	+++
Improving soil resources (OM, nutrients)	+++
Improving of water resources	+++
Improving water productivity	++
Natural disaster prevention / mitigation	+++
Climate change mitigation / adaptation	+++

Climate change mitigation	
Potential for C Sequestration (tonnes/ha/year)	no data
C Sequestration: above ground	+++
C Sequestration: below ground	+++

Climate change adaptation	
Resilience to extreme dry conditions	+
Resilience to variable rainfall	+++
Resilience to extreme rain and wind storms	+++
Resilience to rising temperatures and evaporation rates	+++
Reducing risk of production failure	+++

Origin and spread

Origin: Prior to the colonial era, the sacred character of forests helped to conserve them as part of traditional community resource management systems. After the 1992 Earth Summit, Central African countries adopted laws and regulations including sustainable management plans, community involvement and conservation objectives. However, the execution of these regulations is not sufficiently successful.
Spread of rainforests: 180 million ha are covered by rainforests (out of 582 million ha of forests). They are mainly found within the Central African Republic (CAR), the Democratic Republic of Congo (DRC), Equatorial Guinea (EG), Gabon and the Republic of Congo. Rainforests are also found in Cameroon, the high mountain areas of Ethiopia, Kenya, West Africa (e.g. Benin, Ghana, Guinea Bissau, Guinea, Ivory Coast, Liberia, Nigeria, Sierra Leone and Togo) and in costal zones in South Africa, Madagascar, etc.
Sustainable rainforest management mainly in: Forest management plans are in effect in Cameroon, Congo, Gabon and CAR. Cameroon and CAR have more than 75% of the concession with agreed management plans, whereas the larger DRC has none. In Central Africa, the forest area certified by the Forest Stewardship Council (FSC) was about 4.7 million ha in 2009: Cameroon (0.9 million ha), Congo (1.9 million ha) and Gabon (1.9 million ha). Cameroon, CAR and EG have more than 20% of their land under protection, whereas in Congo, DRC and Gabon the protected area ranges between 9-11% of the total land area.

Principles and types

Good Forest Governance is a prerequisite for sustainable rainforest management (SRFM). It is presently pursued through three approaches: (1) the Forest Law Enforcement and Trade (FLEGT) process; (2) independent third party observers; and (3) forest certification and / or legal systems operating in the Congo Basin.
Land use planning: SRFM needs to be part of a broader national land use planning process. All stakeholders from small farmers, communities, NGOs, the private sector and government technical services should be involved and collaborate very closely - giving special emphasis to social and ecological aspects. A collective assumption of responsibilities is needed, to bring a transformation of responsibilities from state to private structures such as communities, NGOs, and concession-holders. SRFM for carbon, biodiversity and water resources needs global planning and compensation mechanisms.
Community forestry: The management of forests with or by local communities is an important mechanism for addressing social equity while pursuing the sustainability of the forest resources. Maintenance and protection of forest resources can only be achieved through awareness raising and active involvement of communities. For maintaining valuable natural forest resources, clear land tenure and user rights must be given to communities.
Management plan procedures: Inventories on resources potentially available for annual allowable cut / harvest and logging maps are, today, standardised features of any management plan. Through these documents, sustainable logging practices are encouraged and promoted within a forest concession. This includes the demarcation of annual felling coupes (quotas), adherence to minimum harvest diameters, respect for seed-trees to conserve the biodiversity and economic value of the forest – and so forth. The construction of access roads must be carefully planned, as well as timber extraction procedures.
Diversification of production: New niche markets for non-woody forest products, 'green' and 'fair trade' products can increase the competitiveness and income of small-scale producers. Ecotourism involving local communities and Payments for Ecosystem Services (PES) can be promising new income and market opportunities for forest users.
Biodiversity conservation: Beside national and international protected areas, small-scale protected areas may be established at the local level which can preserve habitats and serve as refuges for animals. Protected area management needs to be integrated within the framework of land use planning. These areas, including their buffer zones, must contribute to local economic development through the promotion of NWFP, ecotourism and community forestry. Hunting, where legally permitted, should be controlled and reduced to a sustainable level. Mechanisms to pay for biodiversity conservation need to be established.

Area of rainforests in Sub-Saharan Africa.

Top: Teaching the sustainable use of rattans, Democratic Republic of Congo. (Robert Nasi)
Middle: Pit sawing eucalypt log, Uganda. (Jim Ball)
Bottom: View of natural rainforests in Guinea. (Jim Carle)

Applicability

Land degradation and causes addressed

Small-scale agriculture represents the main threat to the forest since expanding cropland and grazing land at the expense of forest land continues in many areas: it is effectively an intensification of the traditional system of slash and burn. In Central Africa, 32% of the rainforest is allocated to commercial logging concessions granted by governments to companies and individuals. Extensive forest logging does not generally lead to a significant loss of forest cover, and does not compromise forest sustainability directly. Yet forest roads penetrate and open up previously untouched forests, making them accessible, especially for hunting and illegal logging. Logging activities and the selective felling of certain tree species lead to a change in the biodiversity of the forests. Lack of buffer zones lead to polluted water courses. Increasing population pressure and the increasing demand for biofuels, or other NWFPs, may further heighten the threat to the remaining rainforest areas.
Biological degradation: loss of forest ecosystem, biodiversity, and wildlife
Water degradation: decline of water quality and regularity of flow
Physical and chemical soil deterioration: soil compaction, loss of nutrients

Land / forest use

Primary and secondary forests can be defined as natural forests. Within a tropical rainforest, different layers can be distinguished: the ground layer (the forest floor), the shrub layer, the understory, the canopy and the emergent layer.
Naturally, there is only limited use of dense tropical forest, mainly by hunter-gatherers. However, conversion to agricultural land and the application of shifting cultivation have made it possible to use the land for agricultural production. In tropical rainforests the timber market and logging activities play an important role in the use and abuse of the forests.

Ecological conditions

Climate: Tropical rainforests thrive under an annual rainfall of 1,750 - 3,000 mm, and mountain forests between 1,400-2,500 mm. In tropical rainforests, mean monthly temperatures exceed 18°C.
Terrain and landscape: No restrictions; however, in many countries forests have been reduced to inaccessible areas – especially steep hills.
Soils: Soils of rainforests are very susceptible to soil degradation after removal or change of vegetation cover (e.g. after clear cutting).

Socio-economic conditions

Farming system and level of mechanisation: From small-scale land use to mechanised commercial logging activities.
Market orientation: Rainforests are used by subsistence small-scale land users using wood and NWFP as well as for commercial timber or NWFP extraction. The forestry sector is a main job provider for rural population in many Central African countries.
Land ownership and land use / water rights: In most tropical African countries, the state has claimed legal ownership of forest land since the colonial period, even though the customary ownership of the same areas dates back centuries, perhaps millennia. Africa lags behind other tropical forest regions in forest tenure reform with less than 2% of the continent's tropical forests legally owned by, or designated to, forest communities or indigenous groups. To ensure sustainable management of forests, land tenure rights must be ensured for local communities.
Skill / knowledge requirements: SRFM requires a very high level of know-how and technical knowledge regarding appropriate techniques. Good education of forest management services and local communities is a prerequisite.
Labour requirements: Labour requirements vary depending on interventions needed (see principles and types).

Land degradation

Erosion by water
Erosion by wind
Chemical degradation
Physical degradation
Biological degradation
Water degradation

High
Moderate
Low
Insignificant

Land use

Cropland
Grazing land
Forests / woodlands
Mixed land use
Other

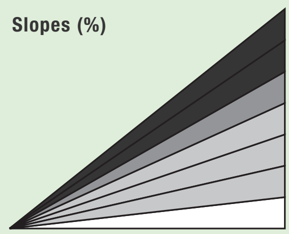
Climate

Humid
Subhumid
Semi-arid
Arid

Average rainfall (mm)

> 3000
2000-3000
1500-2000
1000-1500
750-1000
500-750
250-500
< 250

Slopes (%)



very steep (>60)
steep (30-60)
hilly (16-30)
rolling (8-16)
moderate (5-8)
gentle (2-5)
flat (0-2)

Farm size

Small scale
Medium scale
Large scale

Land ownership

State
Company
Community
Individual, not titled
Individual, titled

Mechanisation

Manual labour
Animal traction
Mechanised

Market orientation

Subsistence
Mixed
Commercial

Required labour

High
Medium
Low

Required know-how

High
Medium
Low

Economics

Establishment and maintenance costs

Since Sustainable Rainforest Management (SRFM) is mainly a political and management issue, the assessment of costs is limited and depends closely on the specific technical and political aspects implemented.

	Cost (US$/ha)	
	Establishment (2-4 year set up phase)	Maintenance (25 years operation)
Community forestry, Cameroon	2,600 – 32,000 (can be up to 59,000)	2,000

(Source: Ingram Verina, see case study on Community Forestry)

Community forestry in Cameroon includes very high establishment costs including marking the boundaries and agreeing on forest use zones, inventory of forest resources, management plans, etc. However, once established the operation of the system is at a low price.

Production benefits

It is difficult to give estimation about the production benefits of SRFM, since the benefits are related to management changes. However, recent studies are helping to put a price on the range of forest goods and services. Yet more research is needed on the value of environmental services such as water quality and supply, soil retention and fertility, carbon storage, and conservation of biodiversity, etc. Furthermore, methodologies are needed to calculate the cost of unsustainable forest management for comparison (FAO, 2008). People living in, and around, rainforests need to be rewarded as stewards / custodians of natural forests. Payments for Ecosystem Services (PES) comprise voluntary transactions for well-defined environmental services. New PES related markets for greenhouse gases, carbon, water and biodiversity are emerging around the world. The PES approach is still recent in Central Africa, and not widely implemented. Yet many sub-regional actors are beginning to pay close attention to this type of mechanism. As for donors, the African Development Bank launched a 'Congo Basin Forest Fund' in 2008 with more than US$ 110 million, which will be partly devoted to setting up PES, including the fight against climate change. Similarly, the World Bank, with its Forest Carbon Partnership Facility, and the United Nations - UNDP, UNEP, FAO - have significant funding for implementing sub-regional programs for reforestation or avoided deforestation. Finally, the Global Environment Facility has started a 'Strategic Program to Support Sustainable Forest Management in the Congo Basin', which is also targeted towards PES. All this funding is for three main environmental services – carbon sequestration, biodiversity conservation, and watershed maintenance – which are just starting to be implemented in Central Africa.

Benefit-cost ratio

	short term	long term	quantitative
Community based forest management	– –	++	No data available

– – negative; – slightly negative; –/+ neutral; + slightly positive; ++ positive; +++ very positive;

Since sustainable forest management is not yet widespread in SSA, it is difficult to make a realistic assessment of the economics, either current or potential, and the likely change to sustainable management during the next two decades.

If communities are willing and economically able to involve themselves, they must receive greater economic benefits from conserving forests than from degrading them. Sustainable natural forest management must tangibly improve local economic welfare, and generate local economic benefits to sufficient levels and in appropriate forms to make SRFM economically sound.

Example: Forest certification

There has been some international recognition of progress made towards sustainable forest management in Central Africa through forest certification. Among several competing processes, the Forest Stewardship Council's (FSC) certification system is considered the most demanding at the international level - focusing not only on technical, but also social and environmental aspects of forest management. From zero hectares at the end of 2005, FSC-certified forest area ballooned to a total of about 4.7 million hectares in July 2009, spread over three countries: Cameroon (0.9 million ha), Congo (1.9 million ha) and Gabon (1.9 million ha) (FSC, 2010 and based on expert knowledge).

Example: Ecotourism Cameroon

In Cameroon the ecological and cultural diversity of the country is an asset for tourism. This could be a means to develop the forest sector outside of timber, woodcrafts and NWFP. Even though Cameroon is trying to make money from biodiversity, through ecotourism, this sector is still underdeveloped. In 2007, tourism revenues, namely ecotourism in protected and hunting areas, amounted to € 297,260 (appr. US$ 365,000). Although some protected areas are visited by tourists there is a lack of adequate structures to valorise their resources. In 2008, 20 protected areas had information centres (Eba'a Atyi R. et al., 2009).

Example: Compensation payments

There are several initiatives in Central Africa to compensate protectors of biodiversity. There are three types: (1) 'freezing' potentially exploitable areas to promote conservation; (2) the labeling of goods produced in compliance with specific environmental standards; and (3) restrictions on practices impacting biodiversity in and around protected areas. Conservation concessions represent the most recent approach in the Congo Basin. The objective is to convert areas earmarked for logging into protected areas. No projects have started yet, but WWF and Conservation International (CI) have made proposals with the goal to conserve the habitat of several major species of large mammals. These conservation concession proposals have yet to convince the national governments to whom the land belongs. The reluctance of public authorities can almost certainly be attributed to the opportunity cost of these conservation concessions - estimated at 10-13 million Euros (US$ 12-16 million) per year - as well as the complexity of national and local institutional arrangements to put in place. (Based on expert knowledge)

Impacts

Benefits	Land users / community level	Watershed / landscape level	National / global level
Production	++ diversification of production ++ increased production of NWFP ++ enhanced long term forest productivity + increased wood production	+++ reduced risk and loss of production +++ improved access to clean drinking water	+ improved food and water security
Economic	++ provides a wide range of wood and non-wood products ++ income diversification (e.g. beekeeping, ecotourism) + increased income	+++ less damage to off-site infrastructure ++ markets for non-woody forest products (diversification) ++ new employment (e.g. ecotourism) and stewardship + stimulation of economic growth	+ improved livelihood and well-being
Ecological	+++ improved protection of biodiversity, endangered forest species and habitats +++ improved forest cover and stocking +++ reduced soil erosion (by water / wind) +++ improved water availability +++ increased soil fertility +++ improved micro-climate ++ restoration and protection of remaining natural forests	+++ water availability +++ water quality +++ reduced degradation and sedimentation +++ intact ecosystem	+++ decreased degradation and desertification incidence and intensity +++ increased resilience to climate change ++ reduced C emissions ++ increased C sequestration ++ enhanced biodiversity
Socio-cultural	+++ recognise value of stewards of natural forests +++ community involvement and strengthening ++ less conflicts among different users ++ improved knowledge and awareness raising on SRFM	+++ increased awareness for environmental 'health' +++ attractive landscape ++ reduced conflicts	+++ protecting national heritage

	Constraints	How to overcome
Production	• Restricted short time use ('exploitation') of forests	➜ awareness of long term benefits and increase of other valuable ecosystem services provided through natural forests
Economic	• Commercial constraints due to uncontrollable international wood markets • Availability of market for non-woody products and ecotourism • Insufficient payments for ecosystem services (PES)	➜ support the establishment of markets for NWFP and ecotourism ➜ improved national and international support and more efforts needed in establishing fair PES mechanisms
Ecological	• Impossibility of reconstituting forests exactly as they were • Difficult to assess the long term impact of a management practice due to the slow-growing of trees • Forest resources are still not sufficiently understood – lack of knowledge and monitoring	➜ promote the role of secondary forests and allow most suitable conditions for regeneration towards natural forests ➜ more investment in research is needed esp. on the contribution of biodiversity, provisioning of water, etc.
Socio-cultural	• Political constraints: secure land tenure of communities often not given, modern and customary laws are often in conflict • Poverty leading directly to indiscriminate extraction of forest resources and dependency on timber market • Knowledge is inadequate, scattered and poorly disseminated • Lack of knowledge on the current state of forest resources • Laws and regulations exist but are not adequately supported, community forest plan may exist, but communities have not enough possibilities to stop illegal logging	➜ allocation of land use rights and consolidating / harmonisation of legal situation including customary laws ➜ improving the livelihoods of poor communities in and around forests and make them independent from destructive forests use, introduce alternative income options through NWFP or ecotourism ➜ compilation and exchange of experiences made with SRFM, learning from others ➜ capacity building of both government staff and community members and regular monitoring and reporting about state of natural forests ➜ needs a clear political commitment and supervision of activities going on

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Adoption and upscaling

Adoption rate

Considerable efforts have been made to implement sustainable forest management approaches to forest concessions in Central Africa (from 125,000 ha in 2000, to over 11.3 million ha in 2008). These figures are likely to increase. However, the rate of SRFM adoption differs greatly between countries. Global concern about sourcing wood from sustainably managed areas is encouraging thanks to the launching of the Forest Law Enforcement, Governance and Trade (FLEGT) process and to the progressive adoption of certification. FSC-certified forest area increased from zero in 2005 to a total of about 4.7 million ha in 2009. However, the overall extent of certification still remains low. Currently, Cameroon is the only country where community and communal forestry concepts are translated into concrete actions.

Upscaling

Political and institutional commitment: Governments must have the political will to shift from industrial logging to community forestry and take actions to do so. SRFM should be integrated into a coordinated national framework with a clear forest policy.

Land tenure rights: Without clear land tenure rights and ownership for communities there is little scope for improving forest management.

Decentralisation and new forest management plans: All stakeholders from small farmers, local communities, NGOs, the private sector, and government technical services must be involved in the development of a management plan. A collective assumption of responsibilities is needed, bringing a transformation of responsibilities from state structures to private structures (NGOs, concession-holders, etc.).

Environmental sustainable logging concession: Logging cannot be banned totally in rainforests, therefore environmentally and socially sound solutions must be considered under new concessions. Forest concession should not threaten the livelihoods of local communities and lead to their marginalisation, therefore local management and enterprises should be supported. Clear rules and guidelines must be available and enforced.

Research and improving knowledge of the forest resources: Multidisciplinary approaches are needed to take into account the various aspects of sustainability. Inventories of biodiversity / wildlife habitat are required as well as information and knowledge related to appropriate / reduced impact logging techniques. Further collaboration with research for an all-encompassing view of natural resources and ecosystems is needed.

Awareness raising and capacity building: Local forestry services should be well educated and trained to coordinate and maintain SRFM. Local communities / land users need to have a good understanding of all aspects of SRFM - traditional knowledge supported by more scientific concepts.

Protected forests need better involvement of local communities in order to reduce damaging and illegal use of the forests. A prerequisite is establishment of clear regulations and control mechanisms by forest services and local communities to ensure commitment to safeguarding protected forests and benefit sharing (e.g. through ecotourism) among all stakeholders.

Incentives for adoption

Payment for Ecosystem Services (PES) can, and must, increasingly be an incentive for sustainable management. Clear commitments are needed to pay for the maintenance of the remaining forest resources. Certification is another tool to enhance the adoption of sustainable rainforest management.

Enabling environment: key factors for adoption	
Inputs, material incentives, credits	+
Training and education	++
Land tenure, secure land use rights	+++
Access to markets	++
Research	++
Infrastructure	++
Conflicts of interest	++

Forest Governance

Improving forest governance in Central Africa is pursued through three approaches:
(1) The FLEGT (Forest Law Enforcement and Trade) process initiated by the European Union (EU), aims to culminate in the signing of a bilateral Voluntary Partnership Agreement (VPA) between each timber exporting country of the sub-region and the EU. Once signed, the VPAs will restrict timber exports to the EU to wood that meets the legal conditions agreed.
(2) In most countries of the sub-region, the process of linking Independent Observers (IO) with the monitoring of forest operations for greater transparency has been adopted. The IOs are generally recruited among international NGOs working to promote transparency. Cameroon, Congo and Gabon have also worked with the World Resource Institute (WRI) to develop interactive forestry atlases, making it available to users interested in basic information on forest concession management. In development by the Commission for the Forests of Central Africa (COMIFAC), the OFAC (Observatory for the Forest of Central Africa) will help all Central African countries to make a wide variety of forest sector data available in a transparent fashion, including: Forest cover, logging, biodiversity conservation and biodiversity development statistics. The private sector is also involved in initiatives to improve the law on forestry operations and enhance transparency. By the end of 2009, 25 certificates of legality (total area 2.6 million ha) have been granted to logging companies following audits by private auditors. Many companies are also involved in the Forest Transparency Initiative.
(3) Forest certification and / or legality systems operating the Congo Basin.
(Based on expert knowledgement)

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FOREST BEEKEEPING - CAMEROON

Apiculture (beekeeping) has been traditionally practiced for at least a century in Cameroon, with forest-based apiculture increasing in the last two decades. The ancient art of honey hunting, and the more recent apiculture and its products like honey, wax, propolis, bee venom and royal jelly, are examples of non-timber forest products (NTFP). A number of projects were supporting production and marketing, due to the conservation and development benefits of beekeeping. Beekeeping has low establishment costs and requires little land or labour, and by providing a suitable environment for the hives in a favourable location (i.e. forest with a range of melliferous trees and plants and sufficient water available year round) it is possible to sustainably harvest a range of bee products on an annual basis.

For processing of the honey, the honeycomb is filtered and honey can be bottled and sold. Higher value is obtained by packaging and labelling. In Cameroon up to 4 US$/kg can be achieved for good quality honey. It can also be sold for industrial use – for example bakeries, sweets. If combs are washed, the resulting honey-water can be made into wine. Wax needs to be melted and cleaned, and can then be sold 'raw' for a price of about 2-6 US$/kg, or further processed into candles, soaps and creams.

In Cameroon, the consumer market is expanding and a small, niche export market for high quality, certified organic and fair trade wax, honey and propolis, is emerging. The exports to Europe and the US require quality assurance schemes that entail costs, expertise and collaboration between government and beekeepers. The number of hives per bee-farmer can vary considerably from a few up to 150 hives. Approximately 15 hives can be installed per hectare. Beekeepers can be good 'guardians of the forests', because they know that the forest provides both forage and water for the bees, and the water and materials needed to make hives and process apiculture products.

SLM measure	Management
SLM group	Sustainable Rainforest Management
Land use type	Natural forest
Degradation addressed	Indirectly deforestation / overuse of natural forests
Stage of intervention	Prevention
Tolerance to climate change	Unknown sensitivity of bees to climatic extremes; resilience of bees is assumed, but changes in honey quality and quantity depending on forage available with changes in forest cover / structure

Establishment activities

1. Construction of hives (traditional or modern, depending on skills and availability / cost of materials).
2. Place hives on forest trees or on stands, above the level of fires, as well as away from ant and termite colonies.

Maintenance / recurrent activities

1. Wait for natural colonisation or capture a swarm and transfer to hive.
2. Regular (weekly or monthly) checking of hive conditions to ensure that the colony is not disturbed by pests or damaged through wind / rain. In drought periods a shallow bucket of water is provided to the bees. Reparation activities if needed.
3. Harvest honey (as soon as sufficient is available), wax and propolis, using a 'smoker' and clean bucket, leaving brood combs to maintain the colony (usually annually at end of rainy and / or flowering season; depends on location). Harvesting of honey combs often done at night to minimise disturbance of the bees.
4. Filter honey from combs to separate honey and wax; then bottle and pack.
5. Process wax (e.g. washing comb and boiling in water or solar melting box) and melt into moulds, using a press or centrifuge. Comb washing water can be used in honey beer or wine in lidded buckets / basins or bottles or using as fermentation airlock.

Labour requirements

For establishment: low
For maintenance: low

Knowledge requirements

For advisors: medium to high
For land users: low

Photo 1: View of the case study area: mountainous forests in Mount Oku region, Northwest Cameroon.
Photo 2: Women carrying harvested wax.
Photo 3: Modern bee hive.
Photo 4: Traditional bee hive. (All photos by Ingram Verina)

Case study area: Mount Oku region, Northwest Cameroon

Establishment inputs and costs per beehive

Inputs	Costs (US$)
Labour: 10 person-days	40
Equipment / tools: bee suit smoker 4 buckets filtering materials bottles for honey	 10 15 12 10 5
Construction material	2-15
TOTAL	**94-107**
% of costs borne by land users	100%

Remarks: For a start up, 5 beehives are needed. Labour includes collection / purchase of materials. Hives can be made from local materials (e.g. raffia palm, mud, rattan, lianas, grasses, wood, or sawn planks for top bar hives) and by using available tools (machete, axe, knife; lifespan 2-5 years).

Maintenance inputs and costs per beehive per year

Inputs	Costs (US$)
Labour: 15 person-days (US$ 4/day)	60
Construction materials for: replacement / repair hive materials, filtering / harvesting	5
TOTAL	**65**
% of costs borne by land users	100%

Remarks: Labour costs depend on number of hives and distance from household. Costs vary with production level and availability of equipment (knife, mesh filter, buckets). Harvest equipment can be basic and includes smokers (bunch of grass / metal smoker) and bee suits (also made locally).

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly negative	positive
Maintenance	neutral	positive

Remarks: Initial investment in hives often recouped in 2-5 years, depending on level of production.

Ecological conditions

- Climate: subhumid
- Average annual rainfall: 2,000-2,400 mm
- Soil parameters: lateritic clay
- Landform: plateau, valleys, mountain slopes
- Altitude: mountain forests
- Each forest type produces its own honey, with a specific taste, colour, consistency and moisture content determined by the pollen and nectar from the forest plants.

Socio-economic conditions

- Type of land user: small to medium scale, very poor to average level of wealth; individuals or groups; cooperatives are mainly used for marketing products and / or buying material
- Population density: 70-100 persons/km^2
- Land ownership: community forest or individual (titled and not titled)
- Land use rights: legal form of community management; many people keep bees by the forest edge on their farms, usually on privately owned land
- Market orientation: mixed (subsistence and commercial)
- Level of mechanisation: manual labour

Production / economic benefits

+++ Subsistence use and sales of apiculture products e.g. wax / honey / propolis soaps, cosmetic, creams, wine, candles etc.
+++ Increased income
++ Own consumption of honey for food and medicinal use

Ecological benefits

+++ Conservation of forests and particularly melliferous trees
+++ Pollination of forests and crops

Off-site benefits

+++ Pollination in area approx 4-6 km from hive

Weaknesses ➜ and how to overcome

- Pests destroy hives / eat honey (e.g. honey badgers, ants, termites, civets) ➜ relocate hives, stronger / different hive construction, regular checks.
- Theft of hives ➜ patrol forest, make agreements in community, locate hives near farms / houses, chain or lock hive.
- Low production ➜ relocate hives to more forested areas, ensure hive located with < 2 km from water source in dry season.
- Bush fires can destroy hive ➜ agreements with farmers / pastoralists about bush fire patrols in dry season, create fire breaks around hive and support trees.
- Rain can destroy hive ➜ use of metal, sheet, grass, raffia or wood as protective 'roof', place in a 'bee house' of locally constructed materials, or under a simple shelter, and experiment with different designs.

Adoption

Established and knowledgeable beekeepers in a community aid dissemination of technology and spontaneous adoption. The technology of hive building needs to be learned but there are many low-tech, local material designs known, as well as simple designs for 'modern' hives. In the mountainous forests of Northwest Cameroon, both traditional practices are passed on around Mt. Oku as well as being stimulated through cooperatives, associations and business groups, covering some 4,500 beekeepers mainly in Bui, Boyo, Mezam and Donga Mantung divisions.

Main contributors: Ingram Verina, CIFOR-Cameroon; Yaounde, Cameroon; v.ingram@cgiar.org
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COMMUNITY FORESTS - CAMEROON

The 1994, Cameroon forestry law introduced the concept of community forests (CF), which gives communities the right to access forest resources in or around their villages, for an area up to 5,000 ha, over a period of up to 25 years. Villagers are allowed to manage, conserve and exploit the products of their CFs in a participatory manner. A manual of procedures guides the process of creating and managing a CF. Basic stages include:

(1) Inform the community of their rights, obligations and procedures;
(2) Select / create a suitable, legal community entity to manage the forest;
(3) Mark the boundaries and agree forest use zones;
(4) Inventorise the forest resources, such as timber species and NTFP;
(5) Hold consultation meetings to agree on forest use, zones and plans;
(6) Complete application file by the community and send to government;
(7) Draw up a management plan for a 5-year period, including the distribution of revenues in the community;
(8) Obtain the necessary felling permit for timber;
(9) Exploit forest and implement activities according to the management plan;
(10) Carry out annual review of logging exploits by ministry;
(11) Monitor revision of, and approve, the management plan (5-yearly).

Once the exploitation permit based on the management plan has been obtained, communities can start to exploit on an annual basis. Often small logging enterprises are contracted for timber extraction. Where the focus is on non-timber resources - e.g. *Prunus africana* in the Northwest and Southwest – these may be exploited collectively or individually. Activities also include hunting, farming, and management of the forest to secure environmental services. Revenues from forest resources should be distributed according to the management plan, involving payments for extraction and control services (patrolling for checking on fires, etc.), as well as contributions to the forest management institution and to community development projects (e.g. schools).

Results in Cameroon are mixed: Over 400 CFs have been requested since 1996, of which 174 are operating while the rest are still waiting to be approved. In 40% of the operating CFs timber is exploited. Issues of concern however include: (1) inequitable distribution of benefits and 'capture' by elites, contractors and NGOs; (2) low profits resulting from artisanal extraction methods and scale, and (3) the long and difficult process to obtain the permission. Determinants of CFs' success include: (1) communities' technical and managerial capacities; (2) access to market information about timber and non-timber prices and buyers; (3) access to finance and equipment.

Type of approach
Project / programme based innovation, incorporated into legal framework

Problems / constraints addressed
– Often low level of management and administration skills to obtain and then manage a CF
– Overcoming competing interests in forest use by communities
– Ensuring that all forest users benefit equitably from their community forest

Aims and objectives
– Devolve forest management and exploitation rights to local communities adjacent to forests
– Communities benefit from exploitation of forest resources
– Forest conservation

Target groups
Local communities

Participation and decision-making
All stakeholders / users in a community should be represented in the local institution set up to demarcate, apply for, managing and exploit a community forest, implemented through a management committee, often incorporates traditional authorities in a community, and in collaboration with local Ministry of Forests and Wildlife.

Implemented SLM / other activities
– SLM measures: participatory demarcation and landuse and forest use planning
– Other activities: sometimes community group work e.g. negotiation and conflict resolution, management and book-keeping skills

Implementing bodies
International institutions and NGOs with national government and national NGOs and local communities

Land users' motivation for implementing SLM
Profitability: harvest of timber
Prestige: social pressure to manage their own forest
Improved livelihood: by conserving forest values e.g. water source protection, sacred areas
Rules / regulations: agree on farm and forest land, hunting zones

Photo 1: Communities placing a boundary market at the edge of a forest. (Verina Ingram)
Photo 2: People with their beehives, in a community forest. (Verina Ingram)

Case study area: mainly southern part of Cameroon in the humid and mountain forest areas; 100,000 ha for 404 community forests

Costs and subsidies

Budget: Large set-up costs: average 2,600-32,000 US$/ha (max. 59'000 US$) over 2-4 years; operating costs: average 2,000 US$/ha/year over the 25 year period of a CF.

Approach costs were met by the following contributors / donors:

National government	5%
International NGO	20%
National NGO	20%
Local government	5%
Local community, land users	50%
Total	**100%**

Subsidies financed under the approach:

Externally financed inputs	
Labour	not financed (in kind)
Equipment / tools	Differs by CF: financed by project, leased, owned by a timber contractor
Agricultural inputs	not financed
Construction material	not financed
Infrastructure	not financed

Access to credits

In most cases no credit was provided. If a CF was supported by a programme / project, some receive financial credit to commence logging operations.

Training and awareness rising

- Form of training: on-the-job; forest visits, public meetings, training courses, exchange visits
- Topics: community group management, participative planning, financial management, timber exploitation, forest inventory. Training was provided to villagers and selected community representatives.

Advisory service

The communities have been made aware of the possibility to manage their forests and exploit timber. They were assisted to set up CF's, by projects / programmes, and sometimes also in the operation of the forests.
Method and key elements: advice (by NGOs, government, village elites) on group management, participative planning, financial management, contract negotiation, timber and non timber exploitation, inventories.

Research

Research has been conducted on successes, failures and contentious issues of CF in Cameroon; does it work? Is it really participative? Who benefits and how much? How can governance arrangements be reformed to create impacts intended in the forestry law?

Organisation / capacity development

Most CF's start with a capacity building and awareness raising phase by informing the communities of the CF concept, followed by on-the-job capacity building to set up a suitable functioning community organisation, inventorying forest resources, holding consultation meetings, and how to draw up and implement a management plan.

Benefits of SLM Approach

++ Improved sustainable land management: cost-benefit analysis indicate there are slightly more environmental and economic benefits than costs from CF than not having a CF
++ Adoption of Approach by other land users / projects: multiplier effect to other communities in Cameroon - also across Central African region
++ Improved livelihoods and human well-being: revenues for community from legal timber exploitation, conservation of forest environmental services

Strengths

- Offers legal, long term route for communities to zone and exploit forests, particularly for timber but also non timber products and environmental services.
- Devolves responsibility for forest management and conservation from national government to community level.
- Gives priority to communities to extract timber, rather than to logging companies.

Weaknesses ➜ and how to overcome

- Implementation costs and time can be higher and take longer than revenues ➜ good initial inventory needed to asses revenues.
- Usually external assistance or informed local community members needed for implementation, is a long and complicated process.
- Requirement only to use artisanal logging methods mean profits can be low and losses of timber high, due to wasteful artisanal methods ➜ proposals to modify legislative framework are emerging that make it possible to use more mechanisation and export to more profitable overseas markets.
- Danger of capturing revenues by elites and / or inequitable distribution ➜ support / needed to ensure equitable distribution of benefits.

Sustainability of activities

Once community forestry is up a running and exploitation activities show profitably, communities do continue the approach, but few CFs in Cameroon have more than 3 to 4 years of experience.

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TRENDS AND NEW OPPORTUNITIES

Weaving baskets from sisal: women at work in Eastern Kenya. (William Critchley)

In a nutshell

To make Sustainable Land Management (SLM) and its products, impacts and services more valuable, and / or to connect SLM with emerging g l environmental issues, promising new technologies and opportunities need to be continually explored. Trends and opportunities encompass both technologies and approaches, and are based on new markets and market demands. They often involve new financial mechanisms.

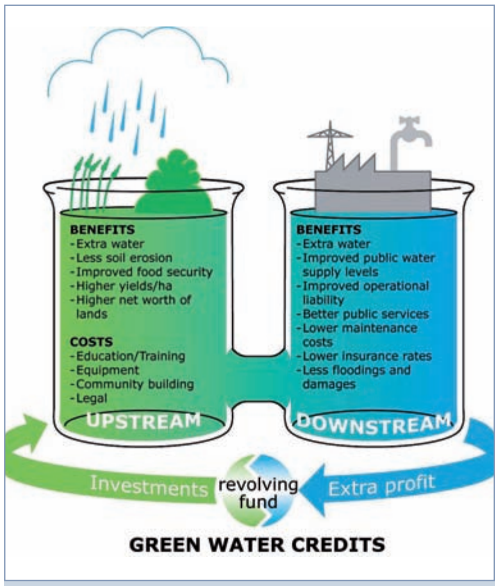
In various areas of agricultural production and agribusiness there is investment potential for small-scale land users, ranging from primary production and food processing to providing services. Some promising trends and opportunities in SSA include:

– Processing agricultural products or 'value chain' development
– New markets for certified agricultural products e.g. Fair Trade, Organic Farming, Forest Certification, etc.
– Markets for endemic plants grown under organic / fair trade conditions (e.g. rooibos tea in South Africa)
– Markets for medicinal plants (many indigenous to Africa, including 'devil's claw'; *Harpagophitis procumbens*)
– Origin labeling (e.g. traditional coffee varieties in Ethiopia, grown under shade)
– Biotechnology for higher yield, improved fruits, new varieties
– Genetically modified crops (BT Maize in South Africa) in combination with conservation agriculture
– Markets for ecotourism and agro-ecotourism
– Markets for bio-energy / fuel
– Markets related to compensation payments e.g. payment for ecosystem services (PES)
– Establishing training, research and agricultural information centers
– Productive gullies for producing cash crops

Furthermore, investment opportunities are related to support services such as establishing farm machinery and equipment plants; tractor hire centers; operating agriculture mechanisation centers; developing human and animal power technologies; seed multiplication farms; training of extension specialists and agricultural researchers. It is likely that increasing attention will be paid to addressing SLM concerns through new marketing opportunities, including wide ranging possibilities for accreditation and labeling schemes to command market premiums. Payment schemes based on PES are almost certainly forerunners for a new breed of programmes and projects. Currently the most promising and important trends and opportunities for SSA are organic farming, ecotourism and PES.

Payments for Ecosystem Services

Payments for ecosystem services (PES) are economic instruments designed to provide incentives to land users to continue supplying an environmental service that benefits society. The payments cover positive externalities, i.e. measures taken in one place that have positive impacts on another location, where currently people benefit from it without paying - which can be viewed as a 'market failure'. Therefore the costs can be internalised; those who benefit from the services pay and those who provide the services receive payment. PES includes voluntary transactions for well defined environmental or ecosystem services (ES) between an ES buyer and an ES provider. The transaction may vary from direct payments to upstream providers from downstream beneficiaries, or between companies paying to compensate for their emissions made in another country. What is being bought must be well defined and can be either a measurable service (e.g. tons of carbon stored) or a change of land use. The payment will naturally only be made if the provider of the services implements the agreed changes. The voluntary nature of the 'transaction' differentiates PES from the conventional command-and-control approach of many governments. Many PES-projects have been started in SSA, paying for carbon storage in forests, watershed services, Green Water Credits, etc. However, there are still many constraints to implementing PES. These include the lack of clearly defined property rights; the measurable and quantifiable input and service that improved land management achieves; assessing and setting the price for ES; limited institutional capacity to set up payment systems, etc.



Example: Green Water Credits
Green Water Credits (GWC) attempts to bridge the incentive gap between upstream and downstream water users. The project implements a regular compensation system by water users to water providers for specified water management services (e.g. for hydropower and irrigation) (Source: ISRIC, 2010).

Ecotourism

Ecotourism can be defined as the purposeful travel to natural areas to understand the culture and natural history of the environment, taking care not to alter the integrity of the ecosystem, while producing economic opportunities that make the conservation of natural resources beneficial to local people. Ecotourism seeks to minimise impacts on the areas visited and contributes to the conservation of these locations and the sustainable development of adjacent areas and communities. Community involvement in ecotourism is important, providing income opportunities and compensating for protecting and limiting use of the ecosystem by the community. Africa is an important ecotourism destination, e.g. the Kenyan Wildlife Service recorded a revenue of US$ 54 million from wildlife tourism in 1995. The protection of forests and other natural habitats are an important aspect of ecotourism. However, the 'ecotourism carrying capacity' is usually not precisely known and facilities are often established without prior assessment of the likely ecological impacts. There is future potential for agro-ecotourism, where the focus of attention is on – for example – ancient terraces combined with traditional farming methods.

Elephants crossing the Samburu river in Kenya. (Hanspeter Liniger)

Biogas Production

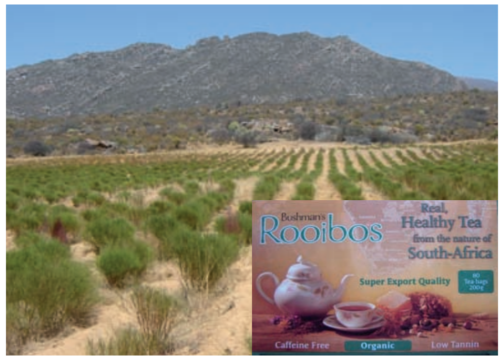
Biogas is gas that is naturally produced during the decomposition of organic waste. The gas is captured in a storage tank (on site) to be used for household energy needs such as cooking, heating and lighting. The most common form of input material is cow dung making it very appropriate for rural settings in SSA. The technology offers two major advantages: (1) On-site and low-cost energy production based on internal inputs; (2) Reduced usage of fuelwood which translates into less cutting down of trees leading to reduced deforestation and land degradation. The biogas plant generally consists of three main chambers: (1) The digester pit where all the microbiological reactions / decomposition of the material takes place; the digester has to be air-tight with the released gas only escaping into the gas holder; (2) The gas holder is connected to the digester through a pipe and collects all the gas that has been fermented; (3) The mixing pit is the input chamber where the dung is mixed with water and fed into the digester. Biogas is suitable either for a farm, cattle post or rural setting where the inputs (cow dung) are easily available. Energy can be saved at every level of use, i.e. individual or institutional. In Botswana for example this technology was introduced by the Rural Industries Innovation Center which is a government funded research institution.

Gas collection tank resting on the concrete-built digester. Pipes / tubes at the top of the gas tank supply the house with methane gas, Botswana. (Reuben Sebego)

Organic Agriculture

Organic agriculture is a holistic production management system that avoids the use of synthetic fertilizer, pesticides and genetically modified organisms. It minimizes nitrogen pollution, conserves soil and water, and optimizes the health and productivity of interdependent communities of plants, animals and people. Organic agriculture farmers need to implement a series of practices that optimize nutrient and energy flows and minimize risk. These include: crop rotations and enhanced crop diversity; different combinations of livestock and plants; symbiotic nitrogen fixation with legumes; application of organic manure; and biological pest control, such as 'push-pull'. All these strategies seek to make the best use of local resources. Findings in a 2008 report issued by UNEP that assessed 114 projects in 24 African countries stated that 'yields had more than doubled where organic, or near-organic practices had been used' and that soil fertility and drought resistance improved. Organic agriculture — with its emphasis on closed nutrient cycles, biodiversity, and effective soil management — has the potential to be more conducive to food security as well as sustainable in Africa than most conventional production systems and has the capacity to mitigate and even reverse the effects of climate change.

Demand for organic and fair trade products is increasing on the international market. These niche markets offer opportunities for small farmers in SSA. However, they demand high quality products and farmers need to meet certification requirements, which can be costly to establish. Furthermore, farmers depend closely on efficient marketing, and need support to access niche markets and fulfil the demand (for example) for specific organic products – including fibres as well as food. Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM), an international umbrella organisation established in 1972.



Top: Rooibos tea bushes in Western Cape, South Africa – and the product marketed in Europe. (William Critchley)
Bottom: Development agencies are promoting export of organic products from Africa. By now more than 50,000 certified organic growers in Uganda. (William Critchley)

Fair Trade

Fair trade is 'aimed at equitable social relations'. It aims to enhance trading conditions for small-scale businesses, improve labour conditions for employees and empower communities through ethical and sustainable trade. It includes producers, traders, retail, support organisations and, of course, consumers of fair trade products. Furthermore, it provides market access to otherwise marginalised producers, connecting them to customers and allowing access with fewer middlemen. Fair trade aims to provide higher wages than those typically paid to producers, as well as helping producers develop knowledge, skills and resources to improve their lives. Fair trade products are traded and marketed either by a 'MEDC* supply chain' whereby products are imported and / or distributed by fair trade organisations (alternative trading organisations, e.g. Max Havelaar) or by 'product certification' whereby products complying with fair trade specifications are certified by them, indicating that they have been produced, traded, processed and packaged in accordance with the standards. Use of labels or certifications for fair trade is mainly a market-driven approach. Fair trade governs land management through consumers' preferences and production demand. A label for organic production or for ecological wood production (FSC) serves as an incentive to implement SLM and allows the land user to gain a higher price for certain products. There are wide-ranging possibilities of labelling schemes. This may even go beyond fair trade and eco-labels and eventually into the realms of 'SLM-friendly' certified products.

The 'Fairtrade certification system' covers a growing range of products in SSA, including, coffee, cocoa, tea, cotton, fresh fruits, honey, spices, shea nut butter (*beurre du karité*), wine, flowers and handicrafts.

* *'Management and Executive Development Centre'*

FAIRTRADE

FLOWER LABEL PROGRAM

'Fairtrade' logos for fair trade products.

Example: Cooperation for Fair Trade in Africa – COFTA.
COFTA is a network of Fair Trade producer organisations in Africa involved and working with disadvantaged grass root producers to eliminate poverty through Fair Trade. COFTA was established by African producers in 2004 and aims to be the African voice in lobbying for greater market access and Fair Trade advocacy for African Producers, thus striving to empower the marginalised and disadvantaged to become organised, active and self-reliant African entrepreneurs. The cooperation is currently composed of over 70 member organisations from 20 African countries. COFTA members are predominantly handicraft producers, but are also involved in tea, coffee, vanilla, honey, dried fruit and juices, textiles among other income generating activities (COFTA, 2010).

Biotechnology and genetically modified crops

Non-GM (Genetic modification) biotechnological practices, such as traditional breeding, grafting / budding, cloning, radiation for mutations, where the organism's genes are manipulated indirectly, are more readily accepted and still have more potential in SSA. Practices that can improve the yield and quality of fruits e.g. grafted mangoes, grafted ziziphus, and budded citrus increase their value on local markets, and hence provide a good source of improved income.

Genetic modification (GM) is a specialised form of biotechnology and involves the manipulation of an organism's genetic make-up by introducing genes with desired traits from other species. GM is considered by some to be an opportunity because of its potential for 'pro-poor' production benefits. However, the whole debate about GM is still very controversial and any prospects for small-scale African land users are estimated to be 20 years away.

Ziziphus fruit in Africa wild (top) grafted (bottom); the grafted 'Pomme du Sahel' (*Ziziphus* sp.) is proving very popular and commands a good market both for fruit and graftlings. (William Critchley)

Productive gullies

Gullies can be rehabilitated for productive use: thus from an erosion problem they can be converted into a source of extra income. Untreated gullies can constitute a significant loss of productive agricultural land. Tree planting, natural grass regeneration and structural measures such as check dams of soil, stones, branches, and micro-basins are common practices that are used to avoid further soil erosion and for rehabilitation. In all cases the gullies then need to be protected from livestock. Such 'treated' gullies can furthermore offer an opportunity to produce more resource-demanding, higher yielding and better revenue crops e.g. fruit trees, banana and sugar cane (e.g. as in Tigray, Ethiopia), nut trees (e.g. cashew), vegetables, rubber, etc. Gully-gardens constitute rich 'micro-environments' being well supplied with water and sediment from above. For this practice to become upscaled, research is required to investigate resource ownership issues related to the gullies and runoff. There may potentially be upstream: downstream conflicts.

Diverse herbaceonsplants, bushes and trees turing the gullies into productive land. (Hanspeter Liniger)

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ORGANIC COTTON - BURKINA FASO

In the Ioba province of Burkina Faso, the production, storage, processing and marketing of organic cotton has been promoted since 2004 by Helvetas.
Organic cotton production adheres to the principles and standards of organic farming. Any application of synthetic fertilizers and pesticides and the use of genetically modified varieties are forbidden. Organic cotton relies on a combination of different measures: (1) the use of organic fertilizers (manure or compost) and recycling of organic matter; (2) crop rotation and / or intercropping; (3) careful selection of varieties adapted to local conditions (climate, soil, pests and diseases); (4) biological pest management (in combination with careful monitoring of crops); (5) clear separation of organic and conventional cropland, e.g. by growing border crops (to avoid contact with chemical substances through spray drift or surface runoff); and (6) soil and water conservation measures. Timely crop management (e.g. weeding) is very important.
In Ioba rotations crops include sesame (a cash crop), cereals and legumes (food crops), while intercrops include leguminous green manure and trap plants. The best adapted cotton variety is FK-37. Bio-pesticides are produced based on neem seeds (*Azadirachta indica*). The measures listed above help to improve soil fertility, reduce production costs (and thus financial risk) and avoid the negative effects of conventional farming: declining yields, resistance to pests and diseases, health hazards and environmental problems caused through the use of chemicals.
By relying on inputs available / produced on the farm and by getting a better price for certified organic products, profitability of the farm is improved in the long run despite of lower productivity compared to conventional or genetically modified (GM) cotton. Farms need to complete a 3-year conversion period to change their production system from conventional to organic. Farmers have to maintain records and documents for periodic inspection and certification (Internal control system).

SLM measure	Agronomic
SLM group	Trends and New Opportunities
Land use type	Annual crops / perennial crops
Degradation addressed	Fertility decline and reduced OM content; Biodiversity decline
Stage of intervention	Prevention and mitigation
Tolerance to climate change	Tolerant to climatic extremes due to higher water retention capacity of soils, reduced erosion and crop diversification (reduced risk of total crop failure)

Establishment activities

1. Purchase equipment (knapsack, etc).
2. Establish compost pits.

Remark: Certification requires a converting period of 3 years.

Maintenance / recurrent activities

1. Compost production.
2. Clear crop residues on fields where cotton will be planted, use for mulch or compost production (no burning).
3. Apply organic manure: 7.5 t/ha.
4. Ploughing (for incorporation of manure, pest and weed control).
5. Sow cotton and intercrops (such as *Hibiscus esculentus* – a trap plant for pests; or *Mucuna* – a green manure plant); Thin out cotton after 10-20 days (1-2 plants per pocket).
6. Weeding (3 to 4 times: 20/40/70/100 days after sowing).
7. Pest control (manual collection); Spraying of bio-pesticide (64 liters/ha, based on neem seeds): according to infestation: up to 3 times.
8. Ridging (form furrows and ridges using plough or manually).
9. Pre-harvest weeding.
10. Harvesting.
11. Cut cotton stems / residues and incorporate into the soil.

Labour requirements

For establishment: high
For maintenance: medium

Knowledge requirements

For advisors: high
For land users: medium

Photo 1: Land preparation using an oxen-drawn plough. (Helvetas)
Photo 2: Spraying bio-pesticides – one element of organic pest management. (Helvetas)
Photo 3: Harvesting cotton. (Jörg Böthling)

Case study area: Dano, Ioba province, Burkina Faso

Establishment inputs and costs per farm

Inputs	Costs (US$)
Labour: 2 person-days	2
Equipment / tools: 15-liter-knapsack	50
Agricultural inputs	na
TOTAL	**52**
% of costs borne by land users	100%

Maintenance inputs and costs per ha per year

Inputs	Costs (US$)
Labour: 145 person-days (at 1.1 US$)	160
Equipment / tools (see establishment)	0
Agricultural inputs: cotton & intercrop seeds, manure, neem seeds	28
TOTAL	**188**
% of costs borne by land users	100%

Remarks: Standard equipment (hoe, plough, wheel-barrow) is not included in costs, knapsack is provided by producer's association (UNPCB) on credit; transport bags are donated. Labour and other inputs for erosion control measures (e.g. stone bunds) are not included in costs. Neem biocide costs US$ 0.7 per liter; organic cotton seeds cost US$ 1.7 per 50 kg.

Benefit-cost ratio

Inputs	short term	long term
Establishment	slightly positive	very positive
Maintenance	very positive	very positive

Remarks: Establishment costs are higher than revenues due to investments & initial decrease in yield (conversion period). On the long term, advanced farmers can achieve same or even higher yields than conventional cotton systems.

Ecological conditions

- Climate: subhumid (tropical, with high rainfall variability)
- Average annual rainfall: 750-1,000 mm per year
- Soil parameters: medium soil fertility, medium organic matter content; sandy or sandy-clayey texture; medium drainage
- Slope: mainly flat (0-2%), partly gentle (2-5%)
- Landform: mainly plateaus / plains, valleys
- Altitude: 300-500 m a.s.l.
- Cotton prefers dry, hot and sunny climate, a minimum of 500 mm of rain distributed over the vegetation period (5 months), deep clay soils (vertisols)

Socio-economic conditions

- Size of land per household: average cotton production area ca. 1 ha
- Type of land user: individual small-scale farmers; men and women; certain activities carried out in mutual help groups
- Population density: 60 persons/km^2
- Land ownership: group (family clans) / state
- Land use rights: individual
- Level of mechanisation: mainly manual labour, partly animal traction
- Market orientation: mixed (organic products for market; other crops such as cereals, legumes and root crops for subsistence)

Production / economic benefits

+++ Improved income: better price due to organic premium (50% more than for conventional cotton) compensates initial decrease of yields
+++ Reduced production costs: less expenses for inputs (- 90% compared to conventional cotton), gross margin is 30% higher
++ Reduced financial risk, less indebtedness for input provision

Ecological benefits

+ Increased soil fertility and increased soil organic matter
+ Increased water holding capacity of soils
+ Increased biodiversity; Eco-balance between pests and beneficial insects
+ No pollution of the environment through toxic chemicals

Socio-cultural benefits

+ Income opportunity for women
+ Enhanced health of humans and livestock (no health risks due to pesticides, diversified and organic food crops)
+ Enhanced organisation (farmers groups)

Off-site benefits

+ Reduced water pollution

Weaknesses ➜ and how to overcome

- Coexistence of organic and GM cotton resulting in high risk of contamination ➜ intensify training of farmers; set up a coordination platform between organic and GM farms; establish a sampling and testing system.
- Insufficient application of manure / compost ➜ training on compost production; Promote supply / production of organic manure (e.g. through small enterprises).
- Large distance to cotton fields (resulting in high transportation costs) due to interfering of browsing livestock close to village ➜ hay-making and corralling of livestock.
- Lack of land, land ownership and land security ➜ promote land leasing; resolve tenure problem on political level.
- Lack of equipment (e.g. plough) ➜ access to credits for small-scale farmers.
- Lack of water ➜ establish water retention structures.

Adoption

Cotton is the top export product in Burkina Faso and other West-African countries (50-60 % of export revenues). The proportion of organic cotton is growing. Actually 1% is produced organically. Around 7,000 farmers are producing organic cotton in Burkina Faso, of whom 28% are women.

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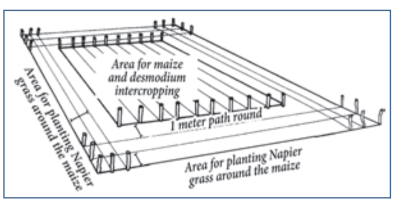
PUSH-PULL INTEGRATED PEST AND SOIL FERTILITY MANAGEMENT – KENYA

In the Lake Victoria region - like in many other parts of Sub-Saharan Africa – stemborer pests, striga weeds and poor soil fertility are the main constraints to efficient production of cereals. In combination they often lead to complete crop failure. The 'Push-Pull' technology efficiently controls the pests and progressively improves soil fertility. It involves intercropping maize with a repellent plant, such as desmodium ('push'); an attractant trap plant, such as napier grass (*Pennisetum purpureum*) is planted as a border crop around this intercrop ('pull').

The stemborer moths are attracted to volatile compounds emitted by the napier grass which at the same time serves as a haven for the borers' natural enemies. When moths lay eggs on napier grass a sticky substance secreted by the grass physically traps the moths' larvae. Napier is also an important carbohydrate-rich fodder grass. Desmodium, a perennial cover crop, produces repellent volatile chemicals that push away the moths, and the plant effectively suppresses striga weeds through its root exudates. Furthermore, desmodium fixes nitrogen, conserves soil moisture, enhances arthropod abundance and diversity and improves soil organic matter, thereby making cereal cropping systems more resilient and adaptable to climate change. Being a low-growing plant it does not interfere with the crops' growth.

Push-pull simultaneously improves cereal productivity; enables production of year-round quality fodder - thereby allowing for integration with livestock husbandry; diversifies income streams and enables smallholders to enter into the cash economy. It also improves soil fertility; protects fragile soils from erosion and enables a minimum tillage system. The technology is appropriate to resource-poor smallholder farmers as it is based on locally available plants, affordable external inputs, and fits well with traditional mixed cropping systems practiced in SSA.



SLM measure	Vegetative
SLM group	Trends and New Opportunities
Land use type	Annual cropping
Degradation addressed	Fertility decline and reduced organic matter content; Increase of pests / diseases
Stage of intervention	Prevention and mitigation
Tolerance to climate change	Technology is tolerant to climatic extremes

Establishment activities

1. Plant 3 consecutive rows of napier grass (*Bana* variety) around the plot: make planting holes, apply fertilizer (or manure), place 3-node canes or root splits, cover with soil (before rains).
2. Land preparation for desmodium: plough and harrow the land (to get fine soil), make furrows between the rows where the maize will be planted (using strong pointed stick; before rains).
3. Mix desmodium seed with super phosphate fertilizer (ratio 1:2), or alternatively with fine soil. Sow into the furrows and cover with soil (onset of rains).
4. Plant maize.
5. Weeding of maize, desmodium and napier grass (3 and 5-6 weeks after planting maize).
6. Manage napier grass: 1st harvest after 3 months (plants are 1-1,5 m high), leave stem height of 10 cm for quick regrow, start with inner row.
7. Cut desmodium for livestock fodder, leave a stubble height of 6 cm; or let it flower for seed production (and cut at a later stage for fodder).

Maintenance / recurrent activities

1. Land preparation for maize: carefully dig / plough between desmodium lines not to disturb / uproot the desmodium.
2. Plant maize.
3. Trim the desmodium so that it does not overgrow in between the maize plants (after 3 and 6 weeks).
4. Repeat activities 5.-7. listed under establishment.

Labour requirements

For establishment: medium
For maintenance: low

Knowledge requirements

For advisors: medium
For land users: low

Photo 1: A dense barrier of napier around the maize plot; Spacing of napier plants should be 75 cm between rows and 50 cm between plants within a row.
Photo 2: Desmodium is drilled in between maize rows at 75 cm row to row distance.
Photo 3: Overview of a push-pull plot (max 50 m x 50 m). (All photos by ICIPE)
Technical drawing: Layout of push-pull plot with1 m spacing between napier border and maize field. (ICIPE)

Case study area: Lake Victoria region, East Africa

Establishment inputs and costs per plot

Inputs	Costs (US$)
Labour: 8 person-days	10
Equipment / tools: planting stick / hoe	0
Agricultural inputs: 1,200 napier root splits or canes; 0.5 kg desmodium seeds; 47 kg superphosphate fertilizer	200
TOTAL	**210**
% of costs borne by land users	100 %

Maintenance inputs and costs per plot per year

Inputs	Costs (US$)
Labour: 6 person-days	7
Equipment / tools: planting stick / hoe	0
Agricultural inputs: 47 kg superphosphate fertilizer	32
TOTAL	**39**
% of costs borne by land users	100%

Remarks: Size of push-pull plot for the cost calculations above = 0.25 ha.
Input prices (in US$): 1 person-day = 1.2 US$; 1 napier root split / cane = 0.14 US$.; 1 kg desmodium seeds = 18.9 US$.; 1 kg superphosphate fertilizer = 0.68US$.

Benefit-cost ratio

Inputs	short term	long term
Establishment	positive	very positive
Maintenance	positive	very positive

Adoption

The technology is based on low external inputs and is adapted to the traditional mixed cropping systems in Africa. To date it has been adopted by over 29,000 smallholder farmers in East Africa, mostly without incentives. Where the technology is being introduced for the first time, farmers only need demonstration and technology information.

Ecological conditions

- Climate: mainly subhumid; bi-modal rainfall pattern, with main rainy season March-May; short rainy season October-November
- Average annual rainfall: 700-1,100 mm per year
- Soil parameters: low fertility, low to medium depth, medium drainage, low organic content; texture is mostly loamy clay, partly sandy
- Slope: < 10 %.
- Landform: mainly valleys, plains, and footslopes.
- Altitude: 1,200 – 1,250 m a.s.l.

Socio-economic conditions

- Size of land per household: 2 ha; production area: 0.9 ha
- Type of land user: small-scale; very poor to poor; mainly Individual farmers, some organised in informal groups
- Population density: 440-850 persons/km^2
- Land ownership: mainly individual (titled or not titled); communal; state
- Land use rights: mainly individual, leased; seldom communal (organised)
- Level of mechanisation: equally manual labour, and animal traction
- Market orientation: mainly subsistence (self-supply), starting small-scale commercial

Production / economic benefits

+++ Increased crop production: maize yields increase by 25-50% where stemborer is the only problem and by 300% in areas affected by stemborer and striga weed
+++ Increased fodder production: all-year round quality fodder for cattle (napier grass and desmodium)
+++ Increased income: selling cereal grains, desmodium seed, napier grass (if not fed to own livestock), and milk
+++ Reduced financial constraints: reduced fertilizer inputs thanks to nitrogen-fixing by desmodium
++ Reduced workload: weeding is minimised

Ecological benefits

+++ Increased soil fertility
+++ Increased soil organic matter
+++ Reduced soil loss: soil protected from erosion through desmodium (cover crop) and napier grass (barrier)
+++ Increased ground cover (cover crop, live mulch)
+++ Increased soil moisture (cover crop, live mulch)
+++ Reduced wind impacts due to napier barriers

Socio-cultural benefits

+++ Social capital generated through common learning and implementing agricultural 'best practices'

Off-site benefits

+++ Improved nutrition and both on-farm and off-farm employment

Weaknesses ➜ and how to overcome

- Napier grass is an aggressive plant that spreads through rhizomes under the ground ➜ regular control and weeding.
- The older napier stems and leaves are less palatable for livestock ➜ regularly cut young, tender leaves and stems.
- Minor adjustment of the smallholder farming system to introduce desmodium in traditional maize-bean intercrops ➜ desmodium (fodder crop) and beans (food crop, important protein source) can both be intercropped with maize. In areas where striga weed is not a problem, farmers can plant desmodium after every 3 or 5 rows of maize, and use the other rows for beans. Stemborers will still be repelled.

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Key references: Biovision. 2010. www.biovision.ch ■ icipe - African Insect Science for Food and Health. 2010. www.push-pull.net ■ Khan Z.R. et al. 2007. A Primer on Planting and Managing 'Push-Pull' Fields for Stemborer and Striga Weed Control in Maize ■ Fischler M. 2010. Impact assessment of Push-pull technology . Intercooperation, Switzerland.

EQUITABLE PAYMENTS FOR WATERSHED SERVICES - TANZANIA

Equitable Payments for Watershed Services (EPWS) is a programme using Payments for Ecosystem Services (PES) to improve rural livelihoods. Incentive mechanisms are used to reward upstream landowners for maintaining a beneficial land use or for adapting a particular land use practice which affects the availability and / or quality of downstream water resources. The EPWS approach has enormous potential to advance a new conservation revolution based on a compensation mechanism encouraging and financing conservation efforts as well as improving the livelihoods of the rural poor.

Equitable Payments for Watershed Services (EPWS) aims to spread SLM technologies to communities, to raise awareness of the benefits of SLM and to improve land productivity. Farmer groups are formed to lead the implementation of SLM. The approach includes supervision, support and training of farmers to ensure appropriate implementation of SLM and efficient soil erosion control. Methods include demonstration plots and farmer-to-farmer extension. Capacity building to farmers (on gender mainstreaming, good governance and relevant laws and policies) and monitoring of hydrological and livelihood status are important components of the approach. Efforts to ensure good women integration resulted in a relatively high proportion within the farmer groups (>35%).

A payment mechanism has been established to compensate farmers for delivering watershed services (in form of freshwater) through implementation of SLM. Compensation payments – paid in cash and through material support – are made first to establish land use changes, and thereafter for service delivery and maintenance. They are mainly covered through international donors (DANIDA) and 'buyers' from the private sector, investing in watershed management.

This PES approach is very new in the country and there is little expertise within the government – which therefore needs to take deliberate efforts to groom experts through seminars and courses on PES mechanisms and its operationalisation. The EPWS team consisting of CARE International, WWF staffs and short term workers (such as students) is always involving government staff in various activities to induce them to knowledge on EPWS in particular and the PES concept at large.

Type of approach
Traditional / indigenous and project / programme based.

Problems / constraints addressed
- Land cover changes due to extensive cultivations
- Deforestation and forest degradation
- Soil erosion, loss of soil fertility
- Low storage capacity of the Uluguru Mountains due to land cover change
- Declining amount of available water in the river coming from Uluguru Mountains
- Increase run-off and sediment load in water system due to bare lands

Aims and objectives
- Improve livelihoods through SLM
- Improvement of hydrological system
- Mechanism to ensure effectiveness, growth and sustainability of EPWS
- Enhance quality of program implementation

Target groups
Land users and land use groups (village farmers, women), SLM specialists (experts on hydrology, GIS, SWC, economics, forests, etc.), politicians and policy makers (district commissioners, ward councillors)

Participation and decision-making
- Interactive implementation and decision making
- Participatory feasibility studies to identify the core problems
- PRA to identify and agree on SLM technologies
- Government staff was involved in various activities e.g. planning, training, data collection and analysis, extension, etc.

Implemented SLM / other activities
Excavation of terraces (esp. *Fanya juu / chini*, bench terraces), agroforestry and reforestation, agronomic practices (intercropping, legume crops), grass strip planting, applications of manure and indigenous pesticides.
Apart from SLM sustainable livelihoods activities were implemented.

Implementing bodies
Care International Tanzania, WWF Tanzania Country Office, DAWASCO and Coca Cola KLtd, Morogoro district council through agriculture officers, communities

Land users' motivation for implementing SLM
Affiliation to the project, environmental consciousness, well-being and livelihoods improvement, payments according to PES.

Photo 1: Man observing maize growth after changing his practices to *Fanya juu* terraces. (Erasto Massoro)
Photo 2: Farmers excavating *Fanya juu* terraces to reduce run off and improve crop production. (Erasto Massoro)

Case study area: Uluguru Mountains, Morogoro, Tanzania; 10-100 km^2 covered by EPWS Approach

Costs and subsidies

Annual budget: 100,000 -1,000,000 US$

Approach costs were met by the following contributors / donors:

International (DANIDA)	60 %
Private sector (buyers)*	9 %
Local community (through labour power)	31 %
TOTAL	**100%**

'buyers' are downstream beneficiaries who pay or provide rewards for managers of the watershed upstream (='sellers')

Subsidies financed under the approach:
Farmers are being compensated (paid in cash) for labour and area provided for the implementation of SLM (opportunity costs). Material support through manure, seeds and working tools is given as well.

Externally financed inputs	
Labour	fully financed (paid in cash)
Agricultural inputs (seeds, fertilizers)	partly financed
Equipment	partly financed

Remarks: The PES system pays for delivering of watershed services which is freshwater (quantity and quality). Payments are made first as compensation to establish land use changes, later for service delivery. EPWS Tanzania is currently facilitating payments for establishment and maintenance of the land use change.

Training and awareness raising

Training was provided to land users by SLM specialists and agricultural advisors. Farmer-to-farmer exchanges with neighbouring communities have improved the capacity of local leaders and farmers' representatives on practical skills on SLM measures, leadership skills, governance, gender mainstreaming, policies and laws to ensure their understanding on the implementation of the EPWS project in their locality.

Advisory service

Included: technical support on monitoring, provision of extension services for improved land use, situation analysis, awareness creation, capacity building on legal issues and mapping of interventions.
People involved: University, foresters, hydrologists, Ministry of Agriculture, land use planners.

Research

Research is a main part of PES as an approach to facilitate SLM adoption and has been very effective in guiding programme design; it included SLM assessment, hydrological analysis, economic analysis, social and livelihoods assessment, etc. All interventions applied were proposed by research conducted before and during implementation.

Organisation / capacity development

Country with limited experts to operationalise the new PES approach. Government needs to take deliberate efforts to groom experts through courses. Government staff is involved in various activities to induce them with knowledge on EPWS.

Benefits of SLM Approach

The project is still in initial stage - impacts can not be fully assessed yet

++ Improved sustainable land management: increased production

++ Improved livelihoods / human well-being

++ Improved situation of socially / economically disadvantaged groups: women have gained training in improving land use practices

++ Poverty alleviation: through change of crop production

Strengths

- Approach rewards land users for providing watershed services
- PES as an additional argument for supporting property claims
- To ensure services are delivered and payments are made and a reliable monitoring mechanism has been put in place
- Poor people are in the centre of the objectives
- PES as an incentive for conservation, helping to change

Weaknesses ➜ and how to overcome

- May reduce the effectiveness of non-incentive based approaches as people will now demand rewards / payments ➜ awareness creation is important to all players including government and local communities.
- Payments / rewards are realised before service delivery ➜ ensure integration of PES with other approaches to ensure effectives short and long term benefits. Paying labour cost upfront while waiting for the service delivery rewards.

Sustainability of activities

Participant land users can continue the activity without additional support-maintenance costs are low and the technologies will improve productivity and resilience of the farming system. Upscaling to neighbouring villages will be facilitated by the establishment of networks of farmers groups to receive training by local extension services. A steering committee, with representatives of the farmers, investors and government offices will facilitate replication in other parts of the country.

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CONSERVATION APPROACH FOR KOURÉ GIRAFFES - NIGER

The giraffe population in Kouré, Niger is unique because: (1) it includes the last representatives of white giraffes (*Giraffa camelopardalis peralta*) worldwide; (2) it thrives in an unprotected environment without any natural enemy (besides man); (3) it is in direct contact with rural communities and its livestock. The giraffe, reduced to only 49 individuals in 1996, was in danger of extinction due to a variety of reasons, the main one being the progressive deforestation in their habitat: the *brousse tigré* savanna vegetation. From 1996-2000, a government programme funded by international development agencies (SNV*, FFEM and the EU) has been carried out to sustainably protect the giraffes and their habitat. This program is based on a participatory approach which actively involves local people in conservation activities, while simultaneously strengthening local development and promoting ecotourism. Its revenues are redistributed to all local actors. A main pillar of the approach was the transfer of responsibilities in natural resources management to local organisations. User groups, a guides' association, a project steering committee, etc. were formed and its members were trained.

Tourism and wildlife observation infrastructure was established – including a visitor's centre, lodging, watch towers, etc. – and tourism activities were organised: Guides are trained, registered and organised into an association. They receive a fixed salary and accompany tourists in turns. Furthermore they support project technicians and researchers in monitoring giraffes and collaborate with the network of government-employed foresters, which has been set up to control the conservation of the habitat.

Tourists pay an entry fee for wildlife watching tours. The revenues and donations are partly used for management and conservation of the giraffe habitat and partly for socio-economic development of the villages (such as infrastructure projects). These revenues are managed directly by the '*communes*' (municipalities).

Thanks to the protection of the savanna vegetation through enclosures for regeneration, prohibition of cutting and closing down of rural wood markets the giraffe population has recovered considerably, comprising 200 individuals in 2008.

**SNV: Netherlands Development Agency; FFEM: French Fund for World Environment; EU: European Union*

Photo 1: Giraffes around the village of Kouré. (Ahmed Oumarou and ECOPAS*) * ECOsystèmes Protégés en Afrique Sahélienne

Type of approach
Project based (PURNKO - *Projet Utilisation des Ressources Naturelles de Kouré*)

Problems / constraints addressed
- Conflicts between giraffes and local population (damage to crops)
- Extinction of giraffes
- Deforestation (giraffe habitat deterioration)
- Rural poverty
- Negative perception of fauna by the population
- Absence of titled land ownership and of adapted forestry laws

Aims and objectives
- Durable and sustainable conservation of the giraffe population in the Kouré area and protection of their habitat.
- Building organisational and management capacity of the local population for protecting the giraffes.
- Fight against poverty by offering supplementary revenue to population through ecotourism (diversification of income).

Target groups
- Agropastoral land users (individuals / groups)
- SLM specialists / advisors
- Planners and decision-makers
- Tourists, women, artisans, teachers and students, national visitors

Participation and decision-making
Initiation: Ministries of planning, environment, tourism and artisan, EU, Association of French Volunteers for Progress (AFVP), SNV, beneficiaries
Planning / implementation: Kouré Guides Association (AGK), groups of beneficiaries, project advisors and animators
Monitoring / evaluation: AGK, groups of beneficiaries, project advisors and animators, department of Environmental Protection
Research: French Center for Agricultural Research for Development (CIRAD), University of Niamey, National Agricultural Research Institute of Niger (INRAN), International Union for Conservation of Nature (IUCN) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Implemented SLM / other activities
SLM measures: planting of palatable trees, semi-circular micro-catchments and planting pits for water harvesting, rill and gully rehabilitation, trenches, small dams, stone lines, enclosures and assisted natural regeneration
Other activities: health, education, infrastructure, trade, micro-credit, river works, forest surveillance

Implementing bodies
International institutions / agencies, national and local government, local communities, land users, researchers

Land users' motivation for implementing SLM
Increased revenue, profitability, improved livelihood

Case study area: Kouré, Tillabéri / Dosso region, Niger; 840 km² covered by approach

Costs and subsidies

Annual budget: US$ 189,000

Approach costs were met by the following contributors / donors:

International: EU	63,3%
International NGO: SNV	18,9%
International: FFEM	17,8%
TOTAL	**100%**

Remarks: Contribution of local populations hadn't been estimated.

Subsidies financed under the approach:

Externally financed inputs	
Labour of populations	not financed
Labour of project technicians	fully financed
Agricultural inputs & construction material	fully financed
Infrastructure (tourism, etc.)	fully financed
Village development funds	fully financed
Giraffe habitat management	fully financed

Access to credits

Through village development fund; micro-credit was allocated without interest to women of women groups for agriculture or livestock production. Repayment occurred after six months. After termination of the project, 'Care International' continued giving credit however with interest.

Repartition of revenues (2007)

Repartition of tourism revenues: 50% for local communities / villages, 30% for giraffe habitat management and 20% for the government.

Training and awareness raising

- Beneficiaries of training program: members of community management committee, land users (women and men), professional guides, advisors
- Form: on-the-job, farmer to farmer, demonstration areas, public meetings, courses, site visits and field trips
- Topics: Conservation technologies and SLM, ecotourism, professional guide skills, organisation of associations, accountancy, agriculture

Advisory service

Dissemination of the approach was by rural animation tools (village planning, rapid PRA, etc.). The Youth Association for Preservation of Natural Resources (AJPREN), U.S. Peace Corps, AFVP and local departments for Environmental Protection ensured a continuous programme of training, environmental education and awareness raising of guides and local people.

Research

Research had been conducted on-farm in collaboration with local populations. Research topics treated were socio- economical, ecological, technical, giraffe habitat and genetics and agricultural.

Organisation / capacity development

The second phase of the project (1996-1998) was entirely dedicated to organisational development including creation of a Monitoring Committee, a decentralised Development Board, a professional Association of Guides, an Informants Network, an Association of Artisans, women groups, 20 management committees of village development funds, etc. On one hand partners have implemented capacity building programmes to train the different stakeholders and on the other hand for financial and logistic support.

Benefits of SLM Approach

+++ Improved sustainable land management: one director for the planning and management of the giraffe area was appointed

+++ Adoption of Approach by other land users / projects: the *ECOsystèmes Protégés en Afrique Sahélienne* (ECOPAS) project adopted (2002) this approach which became the basis for national planning action for giraffes in Niger

+++ Improved livelihoods / human well-being: 3,811 €/village had been distributed to the population of 20 villages through village development funds

+++ Improved situation of socially / economically disadvantaged groups: financial support to women for agricultural production

+++ Poverty alleviation: creation of 13 permanent guide jobs; 900 woman developed agriculture production for marketing

+++ Other: conflicts mitigation (between giraffes and population)

Strengths

- Populations organisation and mobilisation
- Economic, financial and ecological impacts
- Scientific research tools for decision making

Weaknesses ➜ and how to overcome

- Absence of local and national financial contribution ➜ provide regressive grants and promote endogenous funding of activities.
- Approach resulted from exterior initiatives ➜ awareness raising and environmental education to develop 'conservation behaviour' in Niger.
- Uncontrolled fast growth of giraffe population ➜ transfer of giraffes to other protected habitats in West Africa.

Sustainability of activities

After the project was terminated, land users continued this approach without external support based on local development organisations, *Association pour la Sauvegarde des Giraffes du Niger* (ASGN) and Kouré Guides Association (AGK). Since 2002, the research component is being continued by ECOPAS / EU.

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Hanspeter Liniger

SLM APPROACHES AND CASE STUDIES

Awareness of the best SLM technology options is a precondition for spreading SLM. However, how to implement and adapt these practices on the ground and how to create an enabling environment to facilitate this process is a major challenge. Despite continuous efforts over many years the spread and upscaling of SLM practices in SSA has been slow.

In the following section, successful experiences and promising current trends in approaches are presented, in order to assist land users under their specific conditions, and to help indicate what are the most favourable enabling environments for uptake of SLM practices. This is supported by six selected case studies illustrating the variety of approaches that underpin the trend towards successful implementation and adoption of SLM.

Land users and technicians planning SLM interventions in a watershed, Kenya. (Hanspeter Liniger)

In a nutshell

Definition: A SLM Approach defines the ways and means used to promote and implement a SLM Technology - be it project / programme initiated, an indigenous system, a local initiative / innovation - and to support it in achieving better and more widespread sustainable land management. It may include different levels of intervention, from the individual farm, through the community level, and the extension / advisory system at regional or national levels. It may be set within an international framework. Critical analyses of approaches should assist in answering questions about how land users learn about improvements or 'new' technologies, how they obtain skills to apply them, how they are stimulated to adapt technologies and innovate, and how they gain access to required inputs, equipment and financial resources.
A successful approach is usually characterised by being people-centred, responsive and participatory, practical, multilevel and multi-stakeholder, part of a partnership, sustainable (in its socio-economic, institutional and ecological dimensions) and dynamic. An effective SLM Approach comprises the following elements: (1) participants / actors at all levels: policy-makers, administrators, experts, technicians, land users; (2) inputs: labour, material and financial, etc.; (3) know-how: technical, scientific, practical; and (4) the enabling environment: socio-cultural, legal and political (discussed in Part 1).
Approaches that have demonstrated success in SSA include: community-based natural resource management (*gestion des terroirs*), farmer field schools, *animation rural*, various approaches that support farmers' innovations, and the 'Landcare' Approach based on its success in Asia and Australia.

Problems addressed: Lack of technical knowledge, lack of cash to invest in SLM, limited access to inputs, conflicts over resource use, poverty, social inequity, lack of a supporting environment such as markets, prices, infrastructure and services, institutional support, with appropriate laws and regulations. These are intended to address the root causes of low agricultural production through stimulating the adoption and spread of improved SLM.

Intended beneficiaries: Individuals, communities, common interest groups, watershed / catchment / village associations.

Adoption and upscaling: Clearly identified causes of degradation and corrective measures, an enabling policy and regulatory environment are basics for the adoption of the most appropriate SLM measures. Furthermore, the extent of community involvement at different stages from problem identification to decision making and implementation will influence adoption and the potential of an approach to be upscaled. Land users or communities need to feel ownership or identify with the approach and the technology. Approaches and technologies need to go hand in hand and be matched: technologies influence the approach needed and vice-versa.

Development issues addressed are: Food security, rural, urban and peri-urban poverty alleviation, preventing and reversing land degradation, biodiversity and adaptation to climate change.

Distribution:
Participatory Research and Development: Ethiopia, Ghana, Kenya, Senegal, Sierra Leone, Tanzania, Uganda, Zambia;
Participatory Catchment Approaches and Community Based Natural Resource Management (CBNRM): Burkina Faso, Ghana, Kenya, Lesotho, Malawi, Niger, Tanzania, and Zambia;
Information and Communication Technologies (ICT): Kenya and Uganda;
Contracting Extension Services to NGOs and other third parties: promising in Madagascar and Mali;
Farmer Field Schools (FFS): large number of countries, recent developments in Eastern Africa;
Payment for Ecosystem Services: Ghana, Kenya, Tanzania and Uganda.

Evolution of SLM approaches

Approaches can be grouped into three major types: top-down interventions, farmer-first and trans-disciplinary. This typology reflects the broad evolution of approach types and methods over time.

Top-down interventions: Most of the early soil and water conservation - the forerunner of SLM - approaches in SSA during the colonial and immediate post-independence era focused on top-down interventions. These were characterised by lack of land user's participation and 'forced' implementation of externally developed measures (typically coercive terracing and compulsory destocking). In the associated conventional research and extension systems, a form of linear *Transfer of Technology* (ToT) indicated the one-way flow from researcher to extension worker to land users. This model viewed land users, extension agents and researchers as three separate levels with links in one direction only, and no feedback mechanism. In the 1950s and 1960s, the common explanation of non-adoption of technologies was that land users were ignorant. The answer was more *extension teaching*. In the 1970s and early 1980s non adoption by land users was attributed to farm level constraints. The 'cure' was to remove the constraints by input supply and introduction of *Farming Systems research* (FSR). During the late 1980s, and early 1990s the central role of land users was recognised and their non-adoption was explained by technologies that do not fit. The solution was to emphasise *land user participation*.

Farmer first: The new approach made the land user central to programme design and implementation of soil and water conservation activities. It stressed small-scale and bottom-up participatory interventions, often using indigenous technologies and largely rejected the 'conventional' transfer of technology (ToT) model (see above). New approaches based on collaboration between people with local knowledge and researchers developed and were put into practice. The difficulties of implementing land user-led participatory approaches have in turn led to a more focussed approach, in which farmer innovation is driven by the economic, social, institutional and policy environment. In the last few years, the concept has moved from soil conservation towards SLM both at the farm and landscape level. The focus now is on *empowerment of local community groups* by delegating authority, accountability and resources to the most appropriate level and focusing on local technologies.

Trans-disciplinary approach: Research and development is now widely seen as a 'holistic' learning process suggesting that it is a joint process requiring the participation of a wider range of stakeholders (*multi-level and multi-stakeholder*). More importantly, it redefines the role of local people from being merely recipients and beneficiaries to actors who influence and provide key inputs to the process; it links scientific and local knowledge in an interdisciplinary mode, emphasises multi-agency collaboration and is problem- and impact-driven.
However, SLM is often beyond the means, responsibility and decision-making power of single resource users. Instead of solely considering local needs the focus has to be expanded towards regional (watershed / landscape, upstream, downstream) and even national needs (for example irrigation schemes), which might restrict individual freedom of decision-making. At this higher level of intervention, interagency collaboration and the responsibilities of different ministries and institutions should be clearly defined and strengthened.

Main principles

Participatory (collaborative): Involving and giving land users / communities responsibility at all stages.
A participatory approach serves a number of important purposes:
- builds trust and understanding among stakeholders at local, regional and even national level;
- ensures that the perspectives and realities of the intended beneficiaries are accurately reflected;
- empowers marginalised and disadvantaged groups (downstream 'end' users, female land users, disaffected youth, members of minority ethnic groups, etc.);
- fosters ownership of both resources and the process – and thus increases the prospects for adoption.

Participatory methods are relevant from initial policy formulation and programme appraisal, through the different evaluation stages including implementation and improvement, and monitoring and impact assessment at later stages. Key elements are: awareness raising / capacity building, research, extension / advisory service, and organisational development. There is increased use of participatory methods in organisational strengthening, understanding and negotiation of stakeholders' perceptions and increased public accountability. Participatory methods attempt to deal with issues of ownership and control of knowledge, and to reach clarity or consensus between stakeholders as to how, by whom, and against what criteria, the programme is to be measured. Examples of approaches that are underpinned by a strong participatory philosophy are: participatory rural appraisal, participatory technology development and learning for sustainability.

Integrated (multilevel and multi-stakeholder): An integrated approach places people and supportive institutions at the centre of the management and development process, sustaining and enhancing both human and natural capital. Integrated approaches imply a shift from simply bringing together representatives of each sector or projects, towards having them absorb each others' messages and integrating these ideas into their own core work. It must involve researchers, extension agents, communicators and land users in a continuous and interactive way, with the objective of solving land users' problems, using local resources and personnel, and using equipment and buildings in a low-cost manner. Experience has also shown that integrated processes are assisted enormously when they are supported at the highest levels of government. Examples of integrated approaches are: landscape approach (integrated watershed management), livelihoods approach (integrated rural community development), and multi-stakeholder decision-making.

Partnership-based: In a collaborative approach the role of partnerships, platforms and coalitions is to mobilise scientific knowledge for agricultural investments that are pro-poor, pro-growth and pro-environment, to have more equitable partnerships by coupling science and traditional knowledge, achieve a common vision about SLM, provide the right framework to work together to develop policy, govern programs and share information and to target a broad spectrum of stakeholders: policymakers, civil society (NGOs), land users / owners, community-based organisations, research institutions, mass media, and the private sector. TerrAfrica is such a platform.
In addition to these principles and as with technologies, important criteria for an approach to be adopted, adapted and upscaled are that it should be relatively cheap, practical, flexible and sustainable.

Types

Approaches are basically social processes; they do not necessarily follow any systematic classification and there is no absolute best approach - though clearly some work better in certain situations than others. Approaches need to be developed - not selected, transferred or copied - depending on the situation, the people involved, objectives, possible solutions and resources available. In the following, established and contemporary, proven and promising approaches are briefly described:

Participatory Research and Development (PRD) is a pool of concepts and practices that enable people to enhance their knowledge of SLM and strengthens land users' innovative capacity. It is bottom-up, demand-driven and has partly evolved from efforts to improve technology development and dissemination. Participatory approaches are envisioned to (1) respond to problems, needs and opportunities identified by users; (2) identify and evaluate technology options that build on local knowledge and resources; (3) ensure that technical innovations are appropriate for local socio-economic, cultural and political contexts; and (4) promote wider sharing and use of agricultural innovations.

Participatory Learning and Action (PLA): This is a new, alternative name for what was initially (and still often is) termed PRD. Instead of outsiders trying to understand the knowledge of the local people, PLA tries to facilitate local people to develop their capabilities. The emphasis is on participation as a systemic learning process linked to action and change. PLA is the latest term for the basket of 'P' technologies including those that follow below.

Participatory Rural Appraisal (PRA): PRA is an approach developed mainly by NGOs. The approach aims at analysis by people themselves of their own realities and thus the incorporation of the knowledge and opinions of rural people in the planning and management of projects. It includes the use of transect walks, maps, calendars, matrices, and diagrams using locally available materials. PRA evolved from Rapid Rural Appraisal (RRA) - which was modified more in name than in nature as 'participation' was not thought to be compatible with 'rapid'.

Participatory Monitoring and Evaluation (PME) is primarily used in impact assessment and project management. Local people, community organisations, NGOs and other stakeholder agencies decide together how to measure results and what actions should follow once this information has been collected and analysed. It goes beyond the choice of particular methods and techniques to who initiates and undertakes the evaluation process and who learns or benefits from the findings.

Participatory Land Use Planning (PLUP) for planning of communal or common property land, which is particularly important in many communities where communal lands are the most seriously degraded and where conflicts over land use rights exist. Rather than trying to regulate communal lands through national policy, new arrangements can be regulated through negotiation among all stakeholders and communally binding rules for SLM, based on planning units, such as social units (e.g. village) or geographical units (e.g. watershed) can be developed.

Gestion des Terroirs is the best-known example of a **participatory catchment approach** in francophone West Africa. It associates groups and communities with a traditionally recognised land area, aiding these communities in building skills and developing local institutions for the implementation of sustainable management plans. It has focused on natural resource management at the village or community level through: (1) technical projects, such as those related to the conservation of soil, etc; (2) socio-economic factors related to the organisational structures within which people arrange their livelihood strategies; and (3) the legal system and its administration, by which use rights are enforced in practice.

Participatory and Negotiated Territorial Development (PNTD) is rural development through negotiation, participation and dialogue. Developed by FAO, the dialogue process starts with the establishment of international partnerships between the FAO and local government that will lead to the consolidation of a territorial social pact to overcome the social and economic inequalities that affect rural populations, for the eradication of hunger, and for the promotion of social inclusion.

Example: Zimbabwe

An Intermediate Technology Development Group project is located in southern Zimbabwe, where drought occurs in three out of every five years. The approach combines low-cost technologies (water harvesting and subsurface irrigation) with building farmers' capacities to participate in research, extension and within group structures. The benefits of the project, beside doubling the yield, include farmers having acquired new skills for food production; local institutions having been strengthened in tackling their own problems; training has increased confidence among local people, particularly poorest groups; there is increased involvement of women in community decision-making; there is also greater capacity amongst farmers to articulate their needs to service providers, and research and extension systems have become more responsive to farmers' needs (Pretty, 2001).

Top: *Gestion des Terroirs* meeting of village members and technical staff of a SLM project, Niger. (Hanspeter Liniger)
Middle: Participatory Planning with drums in a village, Ghana. (William Critchley)
Bottom: Community's participation at all stages. Treasurer of a forest management project in Niger. (Hamadou Mamoudou)

Community-Based Natural Resource Management (CBNRM): The nature of CBNRM is not simple to define. The concept is related to, and embraces, a variety of terms, including participatory, community, community-based, collaborative, joint and popular natural resource management. It tends to be associated with approaches where the focal unit for joint natural resource management is the local community and resources are subject to communal rights.
Decentralisation is a promising means of institutionalising and scaling-up the popular participation that makes CBNRM effective. However, most current 'decentralisation' reforms are characterised by insufficient transfer of powers to local institutions. Decentralisation reforms present the opportunity to move from a project-based approach toward legally institutionalised popular participation.

Landcare is a community-based approach focused on building social capital to voluntarily resolve local problems affecting the community while preserving land resources. The unique aspect of 'Landcare' is its effective partnership with government and the broader society, including the business sector, in the form of financial and technical advice. In this way, technical knowledge from scientific sources can be integrated with indigenous knowledge and the skills of local people. Although not yet common in SSA (found only in South Africa and Uganda) it is very promising.

Community development / investment funds: Part of a decentralisation policy often includes making funds available to communities for their own development efforts. Depending on the specific situation - which is a function of the donor, the country, and the local needs - the funds may be open or earmarked for specific purposes. The basic concept is that the community has sovereignty over these funds - in other words within a specific domain (for example agricultural intensification), the community decides how to use the funds. Commonly, when allocated to individuals they are paid back into the pool after a number of years, and thus form a local 'revolving fund'. Some such schemes broaden their scope and become, effectively, savings and credit schemes benefiting the community as a whole.

Extension, advisory service and training can be devided into:
1) 'Multiple strategy' which includes several or all of the following: awareness-raising, extension worker to farmer visits, training workshops and seminars around specific themes, exposure visits, hands-on training, and the use of demonstration plots. This is what is adopted by the majority of the project / programme-based approaches.
2) Informal farmer-to-farmer extension and exchange of ideas. Farmer-to-farmer transmission was the only form of 'extension' for thousands of years, and not only has it not died out, but it is being rejuvenated through progressive projects.
3) Trained 'local promoters' that become facilitators / extension workers under a project.
None of these are mutually exclusive. Investment in training and extension to support the capacity of land users and other local and national stakeholders is a priority to adapt better to changing environmental, social and economic conditions, and to stimulate innovation. Examples of innovative extension approaches are: Participatory Technology Development (PTD), Promoting Farmer Innovation (PFI), Participatory Innovation Development (PID) (an umbrella term now covering PFI); Training and Visit (T&V) for promoting technology packages developed by subject matter specialists, Information and Communication Technologies (ICTs), market driven extension, entrepreneurship to support value chains, etc.

Contracting extension services to NGOs and other third parties: NGOs are playing an evolving role in linking and bridging sectors. Many NGOs are forming strategic partnerships with government agencies, private sector and grassroots organisations, and strengthening their technical capacities for scaling-up successful initiatives while continuing to pilot innovative approaches. Over the past few decades, governments in SSA have shifted considerably, from viewing NGOs as a threat, to recognising their valuable role in grassroots implementation of public agendas, often filling gaps in government services and capacity.

Example: Community-Based Natural Resource Management (CBNRM)
In practice, CBNRM is mostly about ways in which the state can share rights and responsibilities regarding natural resources with local communities. At one end of the scale is community participation in protecting, for instance, a national park, without actually involving them in park management. At the other end of the scale is a complete handover of ownership of land and natural resources from the state to communities. Between these two extremes are joint management models, where representatives of the state, acting within the terms of negotiated contracts, manage a state-owned natural resource (for example a lake or forest reserve) together with one or several communities (DANIDA, 2007).

Example: Agroforestry Extension project, Malawi
The Agroforestry Extension project (MAFE) works with some 20,000 farmers on 4,200 hectares to encourage the adoption of various agroforestry practices within farms (e.g. undersowing of pigeon pea and sesbania in maize for soil fertility improvement). The project uses participatory approaches. Farmers are formed into farmer associations, trained as trainers and can ask for specific services from government and non-governmental organisations. As a result, maize yields have improved from 700 kg/ha to 1,500-2000 kg/ha, farmers have become less dependent on fertilizers and more households have become both food and woodfuel secure. Some 6.98 million trees were planted in 1999 by 1,155,900 households, and the project expects to see reduced pressure on natural forests as these mature (Pretty, 2001).

Savings and loans: micro-finance in Burkina Faso. (William Critchley)

Learning for Sustainability (LforS) is an innovative extension approach for facilitating group learning processes concerned with issues relevant to sustainable development. Its main characteristics are: group learning, learning in the local context, a multi-level and multi-stakeholder approach and an active, process-oriented and situated learning. LforS fosters an in-depth understanding of the local context by linking information, knowledge, perspectives and experience from different sources, and by focusing on the dynamics of a given system. LforS is a process-oriented approach that encourages participants to share with each other, to discover common interests and goals, and to develop their own visions.

Farmer Field Schools (FFS) for SLM (and 'farmer study circles' which are more informal) is a group learning approach which builds knowledge and capacity among land users to enable them diagnose their problems, identify solutions and develop plans and implement them with or without support from outside. The school brings together land users who live in the similar ecological settings and socio-economic and political situation. FFS provides opportunities for learning-by-doing. Extension workers, SLM specialists or trained land users facilitate the learning process.

Initiatives for supporting local innovators identify traditional practices with a SLM potential and support recent innovations (e.g. self-help groups, self teaching). Here the 'approach' is basically through transfer of knowledge within a community and through generations. Land users continuously adapt and experiment with new seeds and plants, as well as new practices and technologies, in order to cope with changing environments and new problems. Spontaneous spread may have occurred either recently or through the ages as a tradition. Adoption can be supported by local institutions / community organisations such as land user groups, marketing cooperatives, irrigation and range management associations, women's groups, land user to land user extension groups etc. More attention and support should be given to local innovation as well as to traditional systems, rather than focusing solely on project-based SLM implementation of standard technologies.

Integrated watershed management (IWM) approach aims to improve both private and communal livelihood benefits from wide-ranging technological and institutional interventions. The concept of IWM goes beyond traditional integrated technical interventions for soil and water conservation, to include proper institutional arrangements for collective action and market related innovations that support and diversify livelihoods. This concept ties together the biophysical notion of a watershed as a hydrological landscape unit with that of community and institutional factors that regulate local demand and determine the viability and sustainability of such interventions (i.e. SLM).

Payment for Ecosystem Services (PES) is a rather new approach and carbon markets in particular, offer incentives to mobilise investments to conserve or rebuild forests and vegetative cover, in favor of higher biomass, higher productivity, sustainable agriculture and resilience to climate change. A UNDP and UNEP CDM capacity-building project includes Ethiopia, Kenya and Tanzania.
The Clean Development Mechanism (CDM) allows emission-reduction (or emission removal) projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO_2. These CERs can be traded and sold, and used by industrialised countries to meet a part of their emission reduction targets under the Kyoto Protocol. The mechanism stimulates sustainable development and emission reductions, while giving industrialised countries some flexibility in how they meet their emission reduction / limitation targets.
Other projects are: payments for Reduced Emissions from Deforestation and Degradation (REDD), pro-Poor Rewards for Environmental Services in Africa (PRESA) is providing technical and policy support to small-holder PES projects.

Top: Participants of a training workshop in Mali playing the LforS simulation game 'Sustainable household strategies and community development'. (Ernst Gabathuler)
Middle 1: Learning for Sustainability workshop in a shifting cultivation, Madagascar. (Andreas Kläy)
Middle 2: Farmer Field School on fertilizer micro-dosing in upper east Ghana. (William Critchley)
Bottom: A Farmer Field School group in Bassodawish, Tanzania reflecting on Conservation Agriculture. (Photo CPAR)

Adoption and upscaling

Adoption rate

Participation of land users / communities has often remained wishful thinking due to conflicts and a habitude to adopting a passive role. Under pressure of success, institutions fall back into instruction-oriented behaviour and a lack in confidence in the rural population. Almost the only field of sustained effective extension has been with single commodity approaches for cotton, maize, tea, etc. Nonetheless, participatory approaches are gradually gaining ground across the institutional landscape – from research and academic organisations to NGOs, development agencies, and local government units.

Upscaling

Field experiences show that for innovations to be sustainable there is a need to address not only the technological but also the socio-cultural, political, economic dimensions such as: community structures, gender, collective action, property rights, land tenure, power relations, policy and governance.

However, public sector research and extension, due to several constraints - including financial - are generally unable to develop technologies tailored to a set of individual local conditions (agro-ecological and cultural preferences) hence often produce poorly focused recommendations. The future of extension is in decentralisation of technology testing in highly diverse environments, or in participatory research with land users (inter-disciplinary).

Continuous innovation has been carried out by farmers for millennia. Enabling external institutions, such as NGOs, can play a supportive role in stimulating processes of open discussion and conflict resolution. Researchers and extension workers can further stimulate the ongoing process of innovation and give it a new dimension.

Methods and key elements of technical support

- *Awareness raising*
- *Creating opportunities for information exchange*
- *Using appropriate technologies for information and communication*
- *Training and capacity building*
- *Organisational development*
- *Advisory service*
- *Research*
- *Networking*

Participatory rural appraisal: sharing experiences between Ethiopia, Ghana and Uganda. (William Critchley)

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STRATÉGIE ENERGIE DOMESTIQUE - NIGER

The SED approach (*Stratégie Energie Domestique*: domestic energy strategy) aims at sustainable management of forest resources by delegating responsibility to the communities and increasing their sense of stewardship. The approach was used within PAFN (*Project d' Aménagement des Forets Naturelles*) a long term project in Niger for the management of natural forests. The local people are organised to manage and protect forest resources. On the one hand they carry out controlled, intensive cutting of trees and use of other forest products (gum arabic, honey, fruits, doum palm leaves etc). On the other hand the communities are committed to sustainably managing the forests through SLM technologies, ensuring long term preservation and regeneration of forest resources and maintenance of ecosystem services. Rural wood markets created by the project facilitate wood supply for urban centres and generate permanent income for the rural communities, thus improving their livelihoods. Part of the income is reinvested in sustainable forest management practices. The main aims of the approach are to simultaneously expand woodland areas, enhance controlled cutting, assure provision of urban centres with wood, and guarantee a permanent source of income for rural communities living near the forests. The approach is based on participatory methods, involving local actors at all stages of the project and handing over of major responsibilities to the communities.

The main operational unit of the approach is the so-called SLG (*structures locales de gestion*), a committee at community level, which is responsible for resource management, execution of development activities, monitoring and evaluation and sustainability of investments. Setting-up these organisational structures, as well as training and capacity building of its members is carried out by the project. Once the SLGs are established, planning of development activities and elaboration of forest management plans (PAF) and village forest management plans (PVAF) is done. Then, concrete activities are implemented: establishment of rural wood markets; commercialisation of wood and forest products; establishment of village development funds; implementation of SLM activities. Local people implement project activities at field level. The SLGs are the institutional beneficiaries of the approach, they participate in the management of generated income (e.g. taxes on products sold) and in turn support the mobilisation of local communities. The project provides technical and financial support (for village development funds earmarked for infrastructure projects). A Committee for Science and Technology (CST) with experts from CIRAD France and University of Niamey supervised programme implementation.

Type of approach

Project / programme based

Problems / constraints addressed

– Overuse of fragile natural resources through uncontrolled cutting of trees
– Conflict over natural resources between pastoralists (*Peulhs*) and agropastoralists, lack of social cohesion, exclusion of women
– Lack of financial resources
– Lack of land titles and inadequate laws
– Weak organisational capacity and technical expertise

Aims and objectives

– Stop uncontrolled exploitation of forest resources and increase the population's stewardship of their land
– Ensure fuelwood supply for large population centres (e.g. Maradi, Niamey)
– Combat poverty by providing additional sources of income in the form of new rural wood markets

Target groups

– Land user(s), pastoralists, women, loggers and local merchants
– SLM specialists and advisors, planers and decision makers, teachers and students

Participation and decision-making

National and sub-regional governmental institutions, partnering national NGOs and communities were in charge of managing the project. Planning as well as monitoring and evaluation was done by regional and sub-regional committees (*comités de suivi et évaluation*), NGOs and SLGs. Decision regarding choice of SLM technologies was taken by specialists, after consulting with communities and land users. The implementation was done by the SLG with support from field technicians.

Implemented SLM / other activities

SLM measures: enclosures, natural regeneration (e.g. *Acacia alibida*), vegetative strips (trees / shrubs, fodder plants, grass), stone lines, half-moons, passage ways, mulching with straw and branches, selective clearing, fire control, etc. Other activities: health, education, infrastructure, trade and markets, micro-credits, gardening, poultry farming, beekeeping

Implementing bodies

International institutions together with national / local government, national NGOs, private sector, local communities and land users

Land users' motivation for implementing SLM

Increased revenue, improved livelihoods, payments / subsidies, environmental awareness / health

Photo 1: *Marché de bois* – firewood market of Awanchalla,Illéla,Tahoua.
Photo 2: Training of SLG members. (All photos by Hamadou Mamoudou)

Case study area: natural forests in Niger; 3,723 km² covered by the approach

Costs and subsidies

Annual budget: 1,915,061 US$/year

Approach costs were met by the following contributors / donors:

International institution / agency	89,9%
National government	9%
Local community, land users	1,1%
TOTAL	**100%**

Remarks: African Development Fund, Niger Ministry of Environment / national departments of environment, beneficiaries (SLG)

Subsidies financed under the approach:

Externally financed inputs	
Labour	partly financed
Agricultural inputs	partly financed
Construction material	fully financed
Infrastructure	fully financed
Training, research	fully financed
Project management (technicians, advisors, monitoring, steering, etc.)	fully financed

Remarks: Labour for SLM technologies is an in-kind contribution from the local people. But labour of development activities was paid by the project. Agricultural inputs: seeds, seedlings, imported fertilizers were paid by the project. Seeds collected in the forest and organic fertilizers were supplied by the beneficiaries.

Access to credits

Credits were (mainly) given to women for 'income-generating activities' (fodder, buying of fertilizers, marketing and small trade activities). They were set for six months with an annual interest rate of 20%. Credits were managed by two micro-finance institutions (SICR Kokari, MCPEC).

Training and awareness raising

- Training was provided for the managers of SLGs, advisors, field technicians (NGOs and government) and land user(s). Twelve by the project trained rural animators continued to train SLG members and local animators in the villages.
- Form: On-the-job learning, site visits, farmer-to-farmer, demonstration areas, public meetings, courses, field trips.
- Topics: SLGs approach and organisation, planning at village level, forest law, principles and measures of sustainable forest resource management, management of rural wood markets and of village development funds, methods of rural animation and literacy campaigns.

Advisory service

Extension is provided by NGOs (Karkara, ABC Ecologie) and governmental technical services (at regional and sub-regional level) who work directly with the land users. The methods used are training workshops, training of trainers, monitoring and evaluation as well as Rapid Rural Appraisal (RRA). Financial and material support for inputs are offered.

Research

Research was conducted by the *Institut National de Recherche Agronomique du Niger* (INRAN), University of Niamey, CIRAD France, and local communities. It covered: agro-economy, institutional and energy aspects, training and communication, sociology, forestry and pastoral infrastructure, environmental monitoring, credit systems.

Organisation / capacity development

In each village a local forest management body (*Structure Locale de Gestion* - SLG) was established. All in all there are 113 SLGs. In addition 12 rural markets (9 for doum palm leaves and 3 for gum arabic) were established, each managed by a SLG.

Benefits of SLM Approach

+++ Improved sustainable land management: 6 PAF and 110 PVAF were elaborated and applied by the communities.
+++ Adoption of approach by other land users / projects: The SED has become an integrated part of '*Programme National pour un Environnement et un Développement Durable*' funded by UNDP. Since 2005, all environmental projects have a SED component.
+++ Improved livelihoods / human well-being: 24 school rooms and 4 wells were financed; more than US$ 200,000 of credits were distributed to 2,660 men and women from 2004-2006, etc.
+++ Improved situation of socially / economically disadvantaged groups: pastoralists, women, loggers.
+++ Poverty alleviation: Production and commercialisation activities increased income in the project zone by over 100%.

Strengths

- Organisation and training of local communities
- Enhancing local income and level of economic activity
- Decision support for sustainable management of natural resources (e.g. maps, scientific monitoring methods)

Weaknesses ➜ and how to overcome

- Requires substantial financial and technical means ➜ enhance in-kind contributions from local communities.
- Energy and deforestation problems are not solved sustainably ➜ substitute fuelwood by a more sustainable source of energy.
- Long term control of forest exploitation is needed ➜ establish permanent bodies for ecological monitoring.

Sustainability of activities

The local communities continue implementing the approach without external support; cutting of trees is controlled by the water and forestry department to avoid uncontrolled logging.

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PROMOTING FARMER INNOVATION - KENYA, TANZANIA, UGANDA

The objective of Promoting Farmer Innovation (PFI) is to stimulate technical innovation, in the field of land management, by farmers. The PFI approach seeks to build on technical initiatives – 'innovations' in the local context - developed by farmers themselves in dry / marginal areas where the conventional approach of 'transfer of technology' from research to extension agents, and then on to farmers, has so often failed.
The approach basically comprises identifying, validating and documenting local innovations / initiatives. Simple monitoring and evaluation systems are set up amongst those innovative farmers who are willing to co-operate. Through contact with researchers, extra value is added to these techniques where possible. Farmer innovators are brought together to share ideas. Finally, 'best-bet' technologies, in other words those that are considered to be good enough to be shared, are disseminated through farmer-to-farmer extension. This takes two forms. First, farmers are brought to visit the innovators in their farms. Secondly, farmer innovators are used as teachers / trainers to visit groups of farmers – including FAO's 'farmer field schools' in some cases. Only in this second form of extension is an allowance payable to the innovator. A ten-step field activity methodology has been developed (see figure 1).
At programme level, there is capacity building of in-line extension and research staff, who are the main outside actors in the programme. In each of the countries the approach has been implemented through a government ministry and with NGOs in the field. The principle, and practice, is not to create separate project enclaves, but to work through existing personnel, sharing buildings and vehicles that are already operational in the area. A 'programme development process' methodological framework shows how the ultimate goal of institutionalisation can be achieved (see figure 2). PFI's first phase, completed in 2000, was financed by the Government of The Netherlands, through UNDP, and was active in Kenya, Tanzania and Uganda.
PFI is a potentially important direction for research and extension in SSA. Its principles have been taken up by, amongst others, the UNEP-GEF funded 'Stimulating Community Initiatives in Sustainable Land Management' project.

Figure 1

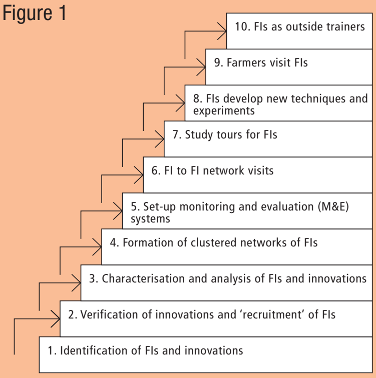
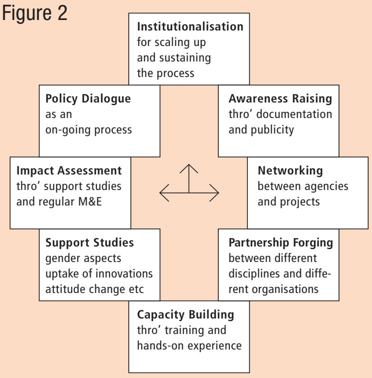


Figure 2



Type of approach
Recent local innovation (stimulated by project)

Problems / constraints addressed
– Poor supply of relevant recommendations from research for small-scale farmers in marginal areas
– Poor delivery of SLM technologies (where they exist) to farmers
– Lack of motivation of research and extension staff
– Isolation of promising 'innovative' SLM ideas which address low crop yields, land degradation and poverty
– Lack of exchange of innovative knowledge

Aims and objectives
Improve rural livelihoods through an increase in the rate of diffusion of appropriate SLM / water harvesting technologies.
– Promotion of farmer-farmer exchange
– Capacity building of farmers and supporting organisations
– Promotion of policy dialogue

Target groups
Land users, SLM specialists / agricultural advisors, planners, politicians / decision-makers

Participation and decision-making
'Best –bet' technologies were pre-selected by extension agents / researchers based on innovative farmers' technologies identified in the field – but the farmers chose which technology to implement.

Implemented SLM / other activities
– SLM measures: runoff harvesting, gully control, composting, etc.
– The approach focussed on SLM only

Implementing bodies
National governments, national NGOs, and land users

Land users' motivation for implementing SLM
Increased production, profitability; improved livelihoods; learning from innovative colleagues

Photo 1: 'Stimulating Community Initiatives in Sustainable Land Management' – a project that follows the PFI methodology: active in Ghana (pictured), Morocco, South Africa and Uganda. (William Critchley)
Figure 1: Field activities: the ten steps - from identification through to using innovators as trainers. (Critchley, 2000)
Figure 2: Programme development processes: the framework of a farmer innovation programme. (Critchley, 2000)
Acronyms: FI: Farmer Innovator, M&E: Monitoring and Evaluation

Case study area: East Africa (parts of Kenya, Tanzania and Uganda); 15,000 km² covered by the approach. Map shows case study area in the districts of Soroti, Kumi and Katakwi, Uganda.

Costs and subsidies

Annual budget: No estimates available

Approach costs were met by the following contributors / donors:

International institution / agency	60%
National government	20%
International NGO	–
National NGO	–
Private sector	–
Local government	–
Local community, land users	20%
TOTAL	**100%**

Subsidies financed under the approach:

Externally financed inputs	
Labour	not financed
Equipment / tools	not financed
Agricultural inputs	partly financed (planting material)
Construction material	not financed
Infrastructure	na
Other	meals during field days, small allowances on study tours

Access to credits

Credits were not provided.

Training and awareness raising

Staff seconded from Ministries of Agriculture / NGOs provide: (1) methodology training for participating staff; (2) presentational skill training for farmer innovators and; (3) training in gender aspects. Training has proved very effective – partially because it was provided on a 'response to need' basis and not predetermined.

Advisory service

Under this approach there are new roles for government / NGO extension staff - as trainers and facilitators. Substantive extension work is carried out by the innovators themselves, through (a) other farmers visiting their plots / homes, and (b) the innovators going outside to act as trainers themselves, either to individual farmers or to train groups as happens under PFI Kenya, through FAO supported 'farmer field schools'. Farmer-to-farmer extension has been a main strength of the programme.

Research

Apart from process monitoring of the methodology, which has led to improvements, technical research into the innovations has been relatively weak.

Organisation / capacity development

The approach had an articulated 'Programme Development Process' procedure, starting with capacity building and moving upwards through networking, impact assessment and awareness raising, towards the final goal of 'Institutionalisation'.

Benefits of SLM Approach

+++ Improved sustainable land management: leads to improved production and soil and water conservation.

++ Adoption of approach by other land users / projects: In each of the three countries Government and NGOs adopted at least certain elements of the approach. UNDP and FAO in Kenya set up a joint 'PFI-Farmer Field School' project.

+++ Improved livelihoods / human well-being: All the innovations were directly related to better livelihoods (as demonstrated in an 'monitoring & assessment' exercise).

+++ Improved situation of socially / economically disadvantaged groups: After evaluation at the end of the first phase a gender-proactive policy (which worked well) was put in place to increase the number of women innovators involved.

+++ Poverty alleviation: The project focussed on poor, small-scale farmers in dry areas.

Strengths

- Builds on local ideas
- Revitalises the extension service
- Is attractive to stakeholders at all levels
- Gives land users more confidence in their own abilities
- Offers new locally tested ideas / technologies which work

Weaknesses ➜ and how to overcome

- Dependent on individual commitment and flexibility; does not follow the conventional institutional chain of command ➜ training in skills and methodologies.
- Sometime confers too much prestige on a particular group of 'favoured farmers' ➜ 'rotate' farmers who are the focus of attention.
- Researchers reluctant to respond to farmers' agenda ➜ effort to convince researchers of benefits of joint research with farmers.

Sustainability of activities

There are examples of spontaneous voluntary continuation of farmer innovator groups in all three countries – but on a reduced level after initial project support ended.

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Key references: Critchley W. 2000. Inquiry, initiatives, and inventiveness: farmer innovators in East Africa. Phs Chem Earth (B), Vol 25, no3, pp 285-288 ■ Critchley W. and K. Mutunga. 2003. Local innovation in a global context: documenting farmer initiatives in land husbandry through WOCAT. Land Degradation and Development (14) pp 143 – 162.

FARMER FIELD SCHOOLS - KENYA

A Farmer Field School (FFS) is a community-based practically-oriented field study programme. It is usually a time-bound activity (generally one agricultural production cycle), involving a group (commonly 20-30) of farmers, facilitated by agricultural advisors or – increasingly – by other farmers. The FFS provides an opportunity for farmers to learn together, using practical, hands-on methods of discovery-based and participatory learning. The methods emphasise observation, discussion, analysis, collective decision-making, presentation and taking appropriate action. Discussion and analysis are important ways to combine local indigenous knowledge with new concepts and bring both into decision-making. The aim is to develop participants' decision-making and problem solving capacity among farmers. The process builds self-confidence (particularly for women), encourages group control of the process, and builds management and leadership skills. Although FFS are time-bound, many groups formalise their relations and continue study or action projects, including FFS on other subjects, after the FFS learning cycle is completed.

The Farmer Field Schools on Integrated Land and Water Management (ILWM) in eastern and central Kenya focus on learning about how to improve management of land and water resources both on individual plot and farm level and within 'landscapes' and communal lands; including local watersheds, river-valleys, forested hill-tops, grazing lands, eroded gullies etc. Each FFS group experiments practically on selected SLM practices / measures. All learning takes place in the field and farmers usually meet once per week at a selected host farm in their locality to monitor their field experiments and to discuss emerging issues. Trained facilitators, usually agricultural advisors, guide farmers in their observation and analysis of what is taking place in the field. Local farmer innovations are identified to feed indigenous knowledge into the FFS process: Innovators visit FFS groups or FFS members visit innovators farms to share their knowledge. The FFS process combined with the promotion of farmer innovation has proven to contribute to strong and cohesive groups that are able to make informed decisions and change cultural and practical behaviour in order to improve their production and land management. The process also builds self-confidence, and empowers especially women to take on leadership roles in the community. The impacts observed of FFS thus have strong biophysical and social dimensions.

Type of approach
Project / programme based

Problems / constraints addressed
– Land degradation, climatic variability and loss of agricultural biodiversity
– Farmers focus on their own farms and income and lack of interest for wider watershed / environment

Aims and objectives
– Support farmers' knowledge levels and decision-making capacity in relation to sustainable land and water management
– Raise farmers' yields in a sustainable manner and ultimately contribute to increased net farm income
– Strengthen community organisation and collective efforts

Target groups
Land users and small-scale farmers / SLM specialists / public rural and agricultural advisors

Participation and decision-making
The land users are actively involved in all phases of the approach and the learning curriculum is based on the problems identified by the group. Each group has its own leadership and management structure and handles its own funds. Extension staff serves as facilitators rather than teachers and focus on methodological aspects of the FFS approach. The technical scope of the learning is determined by the group and specific technical support brought in as needed.

Implemented SLM / other activities
– SLM measures: conservation agriculture, water harvesting, mulching, green manures, improved pasture, composting, integrated plant nutrient management, enhancing on farm biodiversity, etc.
– The approach focuses also on community organisational building for collective action and collective storage and marketing of products.

Implementing bodies
The Food and Agriculture Organisation (FAO) of the UN in collaboration with the Ministry of Agriculture in Kenya

Land users' motivation for implementing SLM
Increased production levels; increased income; also prestige and status in the community (affiliation to a group / network); friendship and collective spirit among group members (especially women)

Photo 1: A FFS group in Nakuru Kenya, monitoring their water harvesting trials in maize during a regular learning session.
Photo 2: A FFS group on a study visit to the Kenya Institute of Organic Farming, Thika.
Photo 3: Training of facilitators in Mwingi and practice on how to use the infiltration ring for measurement of the soil infiltration rate. (All photos by Deborah Duveskog)

Case study area: Eastern and Central Kenya; Mwingi, Kitui and Nakuru Districts

Costs and subsidies

Annual budget: about 100,000 US$

Approach costs were met by the following contributors / donors:

International institution / agency	60 %
National government	20 %
International NGO	–
National NGO	–
Private sector	–
Local government	–
Local community, land users*	20 %
TOTAL	**100%**

Remarks: Community contributions included provision of land, manure, fencing materials, tools etc. and weekly contributions to the group savings account.

Subsidies financed under the approach:

Externally financed inputs	
Labour	not financed
Equipment / tools	fully financed
Agricultural inputs	partly financed
Construction material	not financed
Infrastructure	not financed
Learning materials	partly financed

Remarks: Funding for group level learning; materials and farm inputs were given directly to the group as a grant for them to manage.

Access to credits

No access to credits provided through the approach.

Training and awareness raising

- Agricultural advisors were trained in the FFS approach and in ILWM topics through a total of four weeks of training.
- Farmers were trained in FFS through season-long FFS learning where farmers meet at a 'host-farm' weekly to carry study activities.
- All the training was of practical nature with hands-on practice in the field on the learning subjects, including site visits to farmers and tours to centres of expertise.
- All aspects of ILWM topics were covered in the training.

Advisory service

- Participatory extension with season-long regular interaction between farmers and agricultural advisors. At a later stage also strong farmer-to-farmer extension.
- The approach requires an attitude shift among agricultural extension workers to become more client-orientated.

Research

- Local researchers were involved at the start-up of FFS groups for the sake of providing technical advice as well as to capture farmers' demands for future research priorities.

Organisation / capacity development

- Through the FFS cycle participants develop skills in financial management, leadership, organisational management etc. that form the basis for effective institutional capacity.
- FFS groups regularly interact and visit each other which has led to the creation of networks of federated FFS groups that in many cases have developed into local farmer associations or producer organisations.

Benefits of SLM Approach

+++ Improved sustainable land management: yield increase of more than 200% has been recorded frequently.

+++ Improved livelihoods / human well-being: improved gender relations and division of farm workload, resistance to drought and improved livelihoods and life satisfaction in general.

++ Adoption of approach by other land users / projects: the applied practices have spread from participants to neighbours in the community.

++ Poverty alleviation: all participants fall in the poor or medium poor category and therefore the project has contributed to reduced poverty levels.

Strengths

- The collective action created in communities to deal with and manage their own resources.
- Improved capacity of farmers for problem solving and innovation in ILWM.

Weaknesses ➜ and how to overcome

- A top-down and patronising attitude towards farmers is common among agricultural staff and experts, which prevents equal and trustful relationships ➜ institutionalisation of participatory extension is thus needed with a change in mindset among government and other agricultural support staff.
- The various government bodies and ministries responsible for land and water issues often operate individually without strong synergies ➜ a stronger collaboration is needed between ministries especially Ministry of Water and Ministry of Agriculture in order to deal effectively with land and water aspects in an integrated manner.

Sustainability of activities

Graduated FFS groups have organised themselves into a network and farmer organisations that have taken on collective activities following the end of the initial project. In some cases this has included starting-up self-financed new FFS groups.

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Key references: Duveskog D. 2001. Adapted from A Study Guide for Farmer Field Schools: Water Harvesting and Soil Moisture Retention. ■ FAO-IIRR. 2006. Discovery-based Learning on Land and Water Management: Practical Guide for Farmer Field Schools.

PARTICIPATORY NEGOTIATED TERRITORIAL DEVELOPMENT - BURKINA FASO AND GHANA

Participatory Negotiated Territorial Development (PNTD) is a rural development approach developed by FAO. It offers a structure to build consensus among individual communities and development partners on natural resources / territorial management and development issues. PNTD facilitates consensus based planning within a team that represents different actors at different levels, including sector offices / technical services (agriculture, environment, etc.) and NGOs (involved in community-based rural development) at district / department / municipality level; and traditional authorities, user groups and associations at community / village level.

During the diagnostic phase of the PNTD process, local territorial issues are analysed based on the viewpoints of the different actors and on a historical analysis. This step contributes to a coherent, shared understanding of the territorial system, thus providing the basis for collective agreements on development. These are referred to as Social Territorial Agreements. They are based on negotiation within the PNTD team. Main activities of PNTD include: (1) Facilitation of the planning process; (2) Provision of technical expertise; (3) Linkages to relevant institutions; (4) Technical advisory to assess viability and costs of joint development proposals; (5) Reporting back to communities and provision with final plans and resource maps; (6) Signing of 'Social Territorial Agreements' and endorsement by local government; (7) Establishment of a joint monitoring and evaluation system; and (8) Follow-up meetings between government institutions and NGOs.

Independent external support by territorial facilitators is essential to assist in various aspects of the process. A PNTD approach was piloted within a project in the Onchocerciasis (riverblindess) Freed Zone along the Burkina Faso-Ghana border. This newly opened zone lacked a well defined, accepted management structure to support the development process, while cross-border aspects further complicated development, requiring cooperation among the communities and development partners from both countries. The PNTD team was supported by facilitators from the Netherlands Development Organisation (SNV). The team's capacity to carry out inclusive planning processes has improved significantly, in terms of proposal development, negotiation and consensus building, and in placing the findings of the diagnostic phase in the larger geographical context. Joint development plans were elaborated and agreed upon from the perspective of the communities. FAO has been supporting the exercise through technical backstopping.

Conceptual principles of PNTD

Territorial based:	Social territories (shaped by the social and historical relations between the actors and the territory) are the spatial units of analysis.
Actor based:	Recognition of the heterogeneity of the actors' interests and vision of the territory.
Dynamic:	Understanding of and learning from the changing context and complexity of interactions to support positive patterns and mitigate negative patterns.
Systemic:	Appreciation of the interdependencies within and between territories and their components.
Multi-sectoral:	Integration of environmental, social, economic, political and cultural aspects.
Multi-level:	Recognition of different territorial levels and administrative levels.
Participatory and negotiated	Agreements are developed on the basis of consensus and equal representation of all stakeholders.

Type of approach
Project based

Problems / constraints addressed
– Limited commitment from central governments
– Cross-border planning proved to be considerably more expensive than regular planning activities

Aims and objectives
– Testing a PNTD approach for local (transboundary) territorial planning
– Refining the methodological process
– Preparing a joint development plan for the two areas in Ghana and Burkina Faso

Target groups
Local government (district / department), NGO trainers, community leaders; OFZP national coordinators plus ECOWAS-FAO (Economic Community of West African States) project managers

Participation and decision-making
Initial stakeholder meeting with government representatives, traditional authorities and NGOs was held to introduce PNTD, define pilot area, set composition and tasks of the PNTD team, revise timeframe. Decisions on priority activities were negotiated first within each community and then among communities of the two countries. The PNTD team members acted as facilitators of this process.

Implemented SLM / other activities
– SLM measures: re-forestation, improved livestock rearing, soil conservation, dam construction (between two communities)
– Other activities: a road to link two communities directly

Implementing bodies
SNV (Netherlands Development Organisation) Burkina Faso, SNV Ghana, international and national NGOs

Land users' motivation for implementing SLM
Social pressure (avoiding potential transboundary conflicts) and improving natural resources and land management

Photo left: PNTD can help tackle problems related to territorial disputes and natural resource management. (SNV, Ghana)
Photo right: Dialogue, negotiation and consultation the most significant elements of PNTD. (SNV, Burkina Faso)

Case study area: pilot area covering four communities: Barre and Narquia in the Zecco and Ziou Departements, Nahouri Province, Burkina Faso; and Namoo and Feo, Bongo district in the Upper East Region of Ghana.

Costs and subsidies

Annual budget: No estimates available

Approach costs were met by the following contributors / donors:

International institution / agency	100%
National government	–
International NGO	–
National NGO	–
Private sector	–
Local government	–
Local community, land users	–
TOTAL	**100%**

Subsidies financed under the approach:
No subsidies were given. Labour was not rewarded and inputs were not financed by the project.

Access to credits

No access to credits provided through the approach

Training and awareness raising

A local NGO (BADECC) conducted training of PNTD teams on territorial diagnosis, proposal development, negotiation and conflict resolution. All activities were jointly conducted and attended by participants from Ghana and Burkina Faso. Capacity development took place within the pilot area through a combination of formal training sessions and – preferably – on-the-job training. Training focused on: (1) the PNTD process and its application in the context of cross-border natural resource management; (2) PRA tools relevant to the diagnostic phase; (3) participatory resource mapping (a tool to support the negotiation on development proposals).

Advisory service

This approach focuses on establishing and maintaining social dialogue within the territory and restructuring and / or strengthening territorial institutions.

Organisation / capacity development

The PNTD team's capacity to carry out inclusive planning processes has improved significantly, particularly referring to proposal development, negotiation and consensus building, and in placing the findings of the diagnostic phase in a larger geographical context (interactions between communities). Less impact was achieved from the diagnostic phase as many team members had used the PRA tools before. As PNTD team members work for local (non-) government organisations, the capacity of these institutions to facilitate consensus based planning has also enhanced.

Benefits of SLM Approach

+++ Invoked a high level of interest within the targeted communities; increased active participation, planning and consensus building capacity at community level.

\+ Improved sustainable land management: improved soil conservation and livestock rearing.

Strengths

- Provides a suitable framework for cross-border planning in the West African context.
- PNTD process raised the level of participation of local government institutions and NGOs in a negotiated territorial development process through the PNTD team which comprised technical staff of these organisations.
- PNTD enabled (and stimulated) the communities on both sides of the border to interact, and joint development plans were elaborated and agreed upon from the perspective of the communities.
- Looking beyond community boundaries, and consensus building between communities and stakeholders were new aspects of planning to the team members.

Weaknesses ➜ and how to overcome

- It took time for team members to grasp the conceptual approach of PNTD. They were used to working within individual communities, and if they were involved in planning then mostly at a diagnostic level.
- Language problems required almost continuous translation, and thus effectively doubling the time required ➜ recruitment of linguistic mediator(s) needs to be considered in the project budget.

Sustainability of activities

The PNTD-approach has shown applicability. Yet, there are some aspects which need to be considered: (Local) governments need to take ownership of the cross-border planning and development processes. This could be realised by structuring external support differently: (1) Local government (districts, municipalities) supported by NGO's are responsible to carry out all activities; (2) External (project) support focuses on overall coordination, the provision of technical advice, the provision of operational budgets, and building of partnerships.

Main contributors: Paolo Groppo and Carolina Cenerini, FAO; Rome, Italy; paolo.groppo@fao.org, carolina.cenerini@fao.org
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PARTICIPATORY LEARNING AND ACTION RESEARCH APPROACH TO INTEGRATED RICE MANAGEMENT - MADAGASCAR

The Participatory Learning and Action Research approach to Integrated Rice Management (PLAR-IRM) is a bottom-up, social and experiential learning approach, leading to sustainable agricultural improvements, based on mutual support and communication among farmers. Innovation and agricultural change is aimed for, through capacity strengthening of all major stakeholders involved in the rice sub-sector. IRM refers to the production system and value chain as a whole. Innovation is not limited to technological change; it also includes time management and the building of social networks and institutions for mutual collaboration between farmers and other stakeholders within the rice value chain. A step-wise, self-discovery learning mode encourages the stakeholders to find solutions for their own site-specific problems. During the first years, groups of 25-30 producers are supported by a programme facilitator who animates the learning and innovation sessions. The main instruments are the learning modules dealing with specific crop management practices, harvest and post-harvest practices (involving processors and entrepreneurs also), as well as the agro-ecological and socio-economic conditions of rice production. The sessions aim to strengthen farmers' and other rice stakeholders' capacity to observe, analyse, interpret, make decisions, innovate and share knowledge and experiences. PLAR is based on locally relevant knowledge, practices and skills. Exchanges about current practices, and their logic or justification, are the starting point in all modules.

In a learning-by-doing approach farmers are encouraged to try out any new ideas identified during PLAR sessions on some parts of their fields reserved for new practices ('innovation space'). This allows them to assess the impact of such innovations on their rice yield, or on the profitability of rice growing and the rice business as a whole, and consequently to adapt and fine-tune the measures taken according to their needs. These innovation spaces are regularly visited as part of learning sessions for knowledge sharing between farmers. Since 2005, innovations in land preparation, early transplanting of seedlings, weeds and water management - basically without external inputs - have resulted in three times higher yields, benefitting thousands of farmers. Rice value chain activities started in 2008 with a view to empowering farmers' position within the chains and improving the competitiveness. Groups are unifying into PLAR centres with common marketing of rice, and contract input providers and rice processors.

Type of approach
Programme based

Problems / constraints addressed
- Low yields in rice production; most farmers live below subsistence level
- Absence of government and NGO support
- Limited access to markets, lack of infrastructure

Aims and objectives
- Sustainably improving food security, livelihoods and incomes of poor rice farmers by boosting the profitability of rice production and increasing the efficiency and competitiveness of the rice sub-sector
- Capacity strengthening of all stakeholders involved in the rice-subsector

Target groups
Mainly: land user groups (rice farmers); in 2nd phase: private service providers (e.g. input suppliers), rice processors and buyers

Participation and decision-making
Land users are actively involved in all phases of the approach. The curriculum is based on needs assessment. Decisions on SLM activities to be implemented are taken by individual farmers, and collectively. SLM implementation is done by farmers with technical support from programme officers. Gradually farmers take more responsibility, through the so-called weaning process: decisions on curriculum of training modules are taken by PLAR groups; Farmers' Facilitators (FF) are trained and lead the groups (from the 3rd year on). 5-10 weaned PLAR groups unify in the form of a PLAR centre, mainly dealing with rice value chain related activities.

Implemented SLM / other activities
- SLM measures: land preparation; nursery management; transplanting of young seedling in rows; new rice varieties; improved seed multiplication and conservation practices
- Other activities: value chain development: collective storage and marketing of rice; contractual arrangements with input providers and rice processors

Implementing bodies
International institution / agency (Aga Khan Foundation) operating as a local NGO with support of the local government, local communities and private sector

Land users' motivation for implementing SLM
Production, profitability and affiliation to movements / groups / networks

Photo 1: Farmers discussing development priorities on the basis of the lowland map.
Photo 2: Transplanting rice in lines using a '*fomby*'.
Photo 3: Farmer weeding using a rotative weeder.
(All photos by PSSDRI - *Programme de soutien de la region Sofia pour le développement rural intégré*)

Case study area: Sofia Region, Madagascar; about 10,000 km² covered by approach.

Costs and subsidies

Annual budget: 400,000 US$

Approach costs were met by the following contributors / donors:

International institution / agency	10 %
National government	–
International NGO	–
National NGO	30 %
Private sector	10 %
Local government	–
Local community, land users	50 %
TOTAL	**100%**

Subsidies financed under the approach:

Externally financed inputs	
Labour	not financed
Equipment	fully financed
Agricultural inputs	not financed
Construction material	not financed
Infrastructure	not financed

Remarks: Two *sarcleuses* (weeding equipment) per starting group are provided for free and remain property of the group.

Access to credits

Was supported by the approach in collaboration with an existing microfinance institution; loan period: 6-8 months; monthly interest rate: 2.5%

Training and awareness raising

- Training was given to groups of land users and facilitators
- Form: compulsory and optional PLAR learning modules; on-site experimentation (learning by doing) and farmer-to-farmer exchange during site visits
- Topics: crop management practices, harvest and post-harvest practices (incl. storage, marketing), socio-economic and ecological conditions of rice farming; curriculum based on needs assessment
- Current and planned: expansion of numbers of groups, unification into Centres, value chain activities and extending training sessions for non PLAR-group farmers

Advisory service

- Method and key elements: modular learning sessions guided by a facilitator, farmer-to-farmer extension
- Approach is based on indigenous knowledge

Research

- Local researchers were involved at the start-up of FFS groups for the sake of providing technical advice as well as to capture farmers' demands for future research priorities.

Organisation / capacity development

PLAR groups are formed (new formation or based on already existing entities) for mutual support and exchange of knowledge. In 2nd phase PLAR groups are weaned into higher-level learning and innovation platforms (=PLAR centres) for exchange between farmers facilitators and SLM specialists from the programme.

Benefits of SLM Approach

+++ Improved sustainable land management: yields have increased by > 200% (on innovation spaces).

+++ Adoption of approach by other land users / projects: from 2005-2009 PLAR groups have increased from 6 up to 102, involving 3,782 families and extended to 4,200 non grouped farmers.

+++ Poverty alleviation / improved livelihoods / human well-being: SLM practices result into a net benefit of > 700 US$/ha.

+++ Improved situation of socially / economically disadvantaged groups: marginalised poor rice farmers are targeted.

Strengths

- Farmers learn basic principles of rice management and develop their own locally adapted options for improvements; the innovation comes from inside the groups.
- Farmers build up individual and organisational capacity to find out solutions to their problems and build confidence as efficient partners with other value chain actors.

Weaknesses ➜ and how to overcome

- Labour intensive improvements ➜ provision of group credit to PLAR group members in collaboration with a local microfinance institution.
- Learning intensive approach, with regular group learning sessions ➜ PLAR groups elaborate their own learning programmes and curricula according to their availability and needs.

Sustainability of activities

In a 2nd phase farmers who are organised in PLAR groups gradually build up the capacity to manage the innovation and mutual learning approach on their own without programme support: Farmers' facilitators are trained to take over the lead of PLAR groups with backstopping from programme facilitators.

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Key references: Defoer T., M. Wopereis, S. Diack, and P. Idinoba. 2008. Apprentissage participatif et recherche action pour la gestion intégrée du riz à Madagascar: Manuel du facilitateur AKF, Genève, Suisse. ■ Defoer T., M. Wopereis, P. Idinoba T. and Kadisha. 2006. Participatory Learning and Action Reseaerch (PLAR) for Integrated Rice Management in inland valleys in sub-Saharan Africa: Facilitators' manual. WARDA- the Africa Rcie Center, Bouaké, Côte d'Ivoire.

Case study

‘CATCHMENT’ APPROACH - KENYA

The ‘catchment’ approach promotes sustainable land management systems by conservation of defined areas (termed ‘micro-environments’) through the active participation of the communities living there. It was launched in Kenya in 1988 to achieve greater technical and social impact - at a more rapid pace, than the previous focus on individual farmers. This case focuses on a single ‘catchment’ in a subhumid area of Central Kenya. The emphasis is on structural measures – especially *fanya juu* terraces - but vegetative systems are promoted also. Other activities are supported such as spring protection, improved crop and animal husbandry, agroforestry, fodder production, fish ponds and others. The specific objectives are to stimulate the implementation of a variety of SLM measures leading simultaneously to improved production.

Each approach area is defined by cultural / administrative boundaries rather than strict hydrological watersheds or catchments (as its name confusingly implies). A conservation committee is elected from amongst the focal community before problem identification begins. Technical staff from relevant government and non-government agencies (NGOs) are co-opted onto the committee. The approach then involves participatory methods of appraisal and planning of solutions. Land users, together with the co-opted subject matter specialists, pool their knowledge and resources. Common Interest Groups (CIGs) are formed, with the aim of self-help promotion of specific farm enterprises. Training is given to the members of the CIGs by the Ministry of Agriculture. The farmers carry out the majority of the work themselves: monetary or other tangible incentives are few.

The end result is the micro-environment (catchment area) conserved for improved production, and left in the hands of the community to maintain and sustain. The ‘catchment’ approach was developed under the National Soil and Water Conservation Programme – supported by the Swedish International Development Cooperation Agency (Sida) – and continues to be promoted as the Focal Area Approach (FAA) under the National Agricultural and Livestock Extension Programme (NALEP), which is again supported by Sida. However, under NALEP there is less emphasis on soil and water conservation than under the previous programme, and more focus on promotion of productive enterprises.

Photo 1: An extension officer showing members of a women group how to protect young mango seedlings in the catchment area of Sololo Division, Moyale District, Kenya. (James Njuki)

Type of approach
Project based

Problems / constraints addressed
– Lack of tangible and assessable impact of SLM activities, technically or socially
– Slow implementation of SLM programme
– Underlying problems of poverty, declining soil fertility, soil erosion and fuelwood shortage
– Lack of capital hinders farmers from investing in structures
– Lack of conservation / SLM knowledge

Aims and objectives
To contribute to increased and sustained environmental conservation and improved agricultural production at farm level, through participatory approaches for better land husbandry / SLM.

Target groups
Land users, SLM specialists / advisors, teachers / students, planners, politicians / decision makers

Participation and decision-making
The approach was designed by national specialists. The community was involved in the initiation, planning (public meetings, PRA) and implementation phase. Choice of the technology was mainly by land users supported by SLM specialists and partly by SLM specialists alone. Decision on the method of implementing the technology was mainly by land users supported by SLM specialists.

Implemented SLM / other activities
– SLM measures: *fanya juu* terraces, level bench terraces, agroforestry, fodder production, improved crop and animal husbandry
– Spring protection
– Fish ponds

Implementing bodies
Implemented by community members

Land users’ motivation for implementing SLM
Increased production, profitability and improved livelihood

Case study area: Muranga District, Kenya; 1 km² covered by the approach

Costs and subsidies

Annual budget: US$ 4,000-5,000

Approach costs were met by the following contributors / donors:

International institution / agency	70%
National government	20%
International NGO	–
National NGO	–
Private sector	–
Local government	–
Local community, land users	10%
TOTAL	**100%**

Subsidies financed under the approach:

Externally financed inputs	
Labour	not financed
Equipment / tools	fully financed
Agricultural inputs	partly financed
Construction material	not financed
Infrastructure	not financed

Remarks: Incentives (other than education and motivation) have been used at very low levels. Common Interest Groups (CIGs) were then required to solicit help and assistance as need arises.

Access to credits

Credit was not provided directly, though a 'stakeholder kitty' revolving fund (savings and credit) was promoted and developed.

Training and awareness raising

Training included layout of conservation measures; agroforestry; energy conservation; food preservation – as well as specific farm enterprises. It was carried out for groups and mainly through farm visits by Ministry of Agriculture extension agents. Impact was good for farmers and extension workers.

Advisory service

Extension methods include farm visits; field demonstrations; field days; on-farm demonstrations. The extension service was 'quite adequate' to take this process forward into the future. The impact of the advisory service for farmers and teachers was rated as good, and as excellent for technicians.

Research

Specific problems were researched as they arose. A strong research-extension linkage was / is being built up. Monitoring of the progress of the overall programme is part of the approach.

Organisation / capacity development

A conservation committee is formed including elected members from focal communities and technical staff from relevant government and non-government agencies (NGOs). Common Interest Groups (CIGs) are formed. Support to local institutions was given through training.

Benefits of SLM Approach

++ Improved sustainable land management: mainly through *fanya juu* and level bench terraces.

\+ Adoption of approach by other land users / projects: the further spread of the approach has been limited to one NGO within the case study area.

+++ Improved livelihoods / human well-being: more income generating activities identified and implemented through common interest groups (CIGs) for crop production, marketing and livestock.

++ Others: some enhanced collaboration between agencies; Partners understand each other and avoid activity duplication.

Strengths

- Genuine community participation
- 'Ownership of approach' by the community: feeling that what has been achieved is due to communal efforts and belongs to them
- Improved linkages between extension / training and research
- Promotion of new and productive farm enterprises alongside better SLM

Weaknesses ➜ and how to overcome

- Technologies tend to be implemented uniformly, not site-specifically ➜ match SLM to each particular situation (e.g. promote structural measures only where necessary, i.e. where agronomic and vegetative measures do not provide sufficient protection).
- Uncertainty about continuation in specific areas if direct support stops after only one year ➜ continue approach for at least two or three years in each catchment (approach area).
- Limited area covered by National Agricultural and Livestock Extension Programme ➜ more staff required and more effective use of staff.
- In many places there is a lack of availability of inputs ➜ provide better credit facilities for CIGs / farmers generally.

Sustainability of activities

Interventions are likely to continue and be maintained, but this depends on common interest groups continuing to function actively.

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ANNEX:
BEST SLM PRACTICES COMPARED

For a concise overview, the 12 SLM technology groups that are presented in Part 2 of the guidelines are compared in the following tables:
Table 1: development issues addressed, e.g. production, biodiversity, water, climate change mitigation and climate change adaptation.
Table 2: Benefit-cost ratio.
Table 3: Benefits and impacts at land user and community level, e.g. yields, labour input, improvement of sol and water, community and institutional strengthening, etc.
Table 4: Key factors for adoption including inputs, materials, training and education, land tenure, access to markets, research.

Annex table 1: development issues addressed

	Integrated Soil Fertility Management	Conservation Agriculture	Rainwater Harvesting	Smallholder Irrigation Management	Cross-Slope Barriers	Agroforestry	Crop-Live-stock Management	Pastoralism and Range-land Management	Sustainable Planted Forest Management	Sustainable Forest Management in Drylands	Sustainable Rainforest Management
Development issues addressed											
Preventing / reversing land degradation	++	++	++	+	++	+++	++	++	+++	+++	+++
Maintaining and improving food security	+++	++	++	+++	+	+++	++	++	+	+	+
Reducing rural poverty	++	++	+	++	+	+++	++	++	++	++	+
Creating rural employment	+	++	+	++	+	+	+	+	++	++	++
Supporting gender equity / marginalised groups	++	++	+	++	+	++	++	+++	na	++	+
Improving crop production	+++	++	+++	+++	++	++	++	+	+	+	na
Improving fodder production	+	+	++	+	++	++	++	+++	++	++	+
Improving wood / fibre production	+	na	++	na	+	++	+	++	+++	++	+++
Improving non wood forest production	na	na	na	na	na	+	+	++	++	+++	+
Preserving biodiversity	+	+	+	na	+	+++	++	+++	+	+++	+
Improving soil resources (OM, nutrients)	+++	++	+	+	+	+++	++	++	+	+++	+
Improving of water resources	+	++	+++	-/+	++	++	+	++	na	++	+/ –
Improving water productivity	++	+++	+++	+++	++	+++	++	++	na	++	+
Natural disaster prevention / mitigation	+	++	+	+	++	+++	+	++	+	+++	++
Climate change mitigation / adaptation	++	++	+++	-/+	++	+++	++	++	++	+++	++
Climate change mitigation											
C Sequestration (t/ha/yr) (figures for first 10-30 years of changed land management)	no data	0.57 (+/- 0.141)	0.26-0.46 (+/-0.35) (Pretty et al. 2006)	0.15 (+/- 0.012) (Pretty et al. 2006)	0.5-1 (estimation)	0.3 - 6.5	0.11- 0.81 up to 3 in silvo/ agro-forestry systems (Woodfine, 2009)	0.1 - 0.3 (Schumann et al, 2002 in FAO, 2004)	1.2 – 2 for afforestation in drylands (FAO, 2004 and GTZ, 2009)	no data	no data
C Sequestration: above ground	+	+	+	+	+	++	++	+	++	++	+++
C Sequestration: below ground	+	++	+	+	+	++	++	++	++	++	++
Climate change adaptation											
Increase resilience to extreme dry conditions	++	++	+++	+	++	++	++	+++	+	++	+
Increase resilience to extreme wet conditions	++	++	+++	++	+	+++	++	++	+	+++	++
Increase resilience to variable rainfall	+	+	+	no data	+	++	+	++	+	+++	++
Increase resilience to rising temperatures and evaporation rates	+	++	++	+	+.	++	+	+++	+	++	++
Reducing risk of production failure	++	+	+	++	+	++	++	++	+	+++	+

-- negative; - slightly negative; -/+ neutral; + slightly positive; ++ positive; +++ very positive; na: not applicable

Annex table 2: Benefit-cost ratio

	Benefit-cost ratio		
	short term	**long term**	**Comments**
Integrated Soil Fertility Management	++	+++	A small input in the form of organic and / or inorganic fertilizer can have a significant and immediate impact on crop production. However the profitability depends closely on price and availability of fertilizer.
Conservation Agriculture	+	+++	The short term benefit-cost ratio is mainly affected by the initial cost of purchasing new machinery and tools. The availability and the affordability of these tools can be major obstacles, especially for small-scale land users.
Rainwater Harvesting	– /+ +	++ / +++	RWH techniques can include high initial labour and material input – though there is a wide range. In the long term the benefit-cost ratio depends on the level of maintenance work needed.
Smallholder Irrigation Management	+ / ++	+++	The establishment costs for smallholder irrigation management (SIM) vary considerably. Micro-irrigation systems like drip irrigation require relatively high initial investments, which need to be covered though micro-credit. SIM can help farmers to move towards a mixed subsistence and more commercial system.
Cross-Slope Barriers	–	++	Usually require high initial investment and labour input, therefore the short term profitability is often negative. However vegetative strips can be used as cheap cross-slope barriers option, with much lower establishment costs than terraces, stone lines, etc. Vegetative strips often develop into terraces over time.
Agroforestry	– /+ +	++	Analyses mostly take direct utility values of integrated trees into account, because indirect use values, such as environmental functions, are much more difficult to evaluate. Furthermore, benefit-cost estimates are complicated by the many sources of annual variation affecting tree and crop production and tree-crop interactions. Hence benefits may be in general underestimated. Impact over different temporal scales is an issue that is especially relevant to agroforestry.
Integrated Crop-Livestock Management	+	++ / +++	Integration of livestock with crops improves farm productivity and income; and the benefits can be observed quite rapidly as well as appreciating over time.
Pastoralism and Rangeland Management	no data	no data	Pastoralism has considerable economic value and latent potential in the drylands but little is known or has been quantified. Multiple products and species can make pastoral systems significantly more cost-effective and productive than meat-focused ranching. The value of livestock production in the drylands is probably greatly underestimated in official statistics.
Sustainable Management of Planted Forests	– / – –	+ / ++	Short-time benefits from planted forests are usually negative due to the long establishment period of the trees. Environmental plantations are usually outside the financial perspective of small-scale land users and need therefore financial incentives and / or support for their establishment. The efficiency of plantation management and success in achieving sustainable wood supply depends mainly on whether a plantation is publicly, or privately, owned and managed.
Sustainable Forest Management in Drylands	–	++	Sustainable forest management in drylands is mainly based on community forest management, therefore an estimation of the benefits-costs ratio is very difficult.
Sustainable Rainforest Management	–	++	Once again this is mainly based on community forest management, therefore an estimation of the benefits-costs ratio is very difficult.

– – negative; – slightly negative; – /+ neutral; + slightly positive; ++ positive; +++ very positive

Annex table 3: Benefits and impacts at household and community level

Benefits		Integrated Soil Fertility Management	Conservation Agriculture	Rainwater Harvesting	Smallholder Irrigation Management	Cross-slope Barriers	Agroforestry	Crop-Livestock Management	Pastoralisms and Rangeland Management	Sustainable Planted Forest Management	Sustainable Forest Management in Drylands	Sustainable Rainforest Management
Production benefits	Increased crop yields	+++	++	+ +	+++	++	++	+++	+	na	na	na
	Increased fodder production	++	na	++	na	++	na	++	++	na	na	na
	Increased wood production	na	na	+	na	+	++	na	na	+++	+	+
	Increased production of NWFP	na	na	na	na	na	+	na	na	+	++	++
	Production diversification	+	+	+	++	+	+++	++	++	+	++	++
Economic benefits	Labour reduction	+/ –	+(+)	–	+	–	+/ –	+	+/ –	na	na	na
	Farm income	++	++	++	+++	+	++	++	++	+	+	+
Ecological benefits	Improved soil cover	++	++	+	+	+	++	++	++	++	++	+++
	Reduced soil erosion (by wind / water)	++	++	++	+	++	+++	++	++	++	++	+++
	Improved water availability	+	+++	+++	+/-	++	++	+	+	+/-	+	+++
	Increased organic matter/ soil fertility	+++	++	+	+	+	+++	+++	++	+	++	+++
	Biodiversity enhancement	++	+	+	+	+	+++	++	++	+	+++	+++
	Improved micro-climate	+	++	+	+	+	+++	+	+	++	+++	+++
Socio-cultural benefits	Improved SLM/ conservation/ erosion knowledge	++	++	++	na	+++	++	++	+++	na	++	++
	Changing the traditional gender roles of men and women	+	+	+	++	na	na	na	na	na	na	na
	Community institution strengthening	+	na	++	na	+	+	na	+	+	+++	+++

-- negative; - slightly negative; -/+ neutral; + slightly positive; ++ positive; +++ very positive

na: not applicable

Annex table 4: Key factors for adoption

Enabling environment: Key factors for adoption	Integrated Soil Fertility Management	Conservation Agriculture	Rainwater Harvesting	Smallholder Irrigation Management	Cross-Slope Barriers	Agroforestry	Crop-Livestock Management	Pastoralisms and Rangeland Management	Sustainable Planted forest Management	Sustainable Forest Management in Drylands	Sustainable Rainforest Management
Inputs, material incentives, credits	+++	++	++	+++	++	++	++	+	+	+	+
Training and education	++	++	++	++	++	na	++	+	++	++	++
Land tenure, secure land use rights	++	++	+++	+++	++	++	+++	+++	+++	+++	+++
Access to markets	++	++	++	+++	+	+	++	++	++	++	++
Research	+	++	++	+	++	+++	++	++	+	++	++

-- negative; - slightly negative; -/+ neutral; + slightly positive; ++ positive; +++ very positive
na: not applicable

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Note: Only references used for Part 1 are listed here. References of Part 2 are listed after each SLM group and case study.

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